FIG. 1

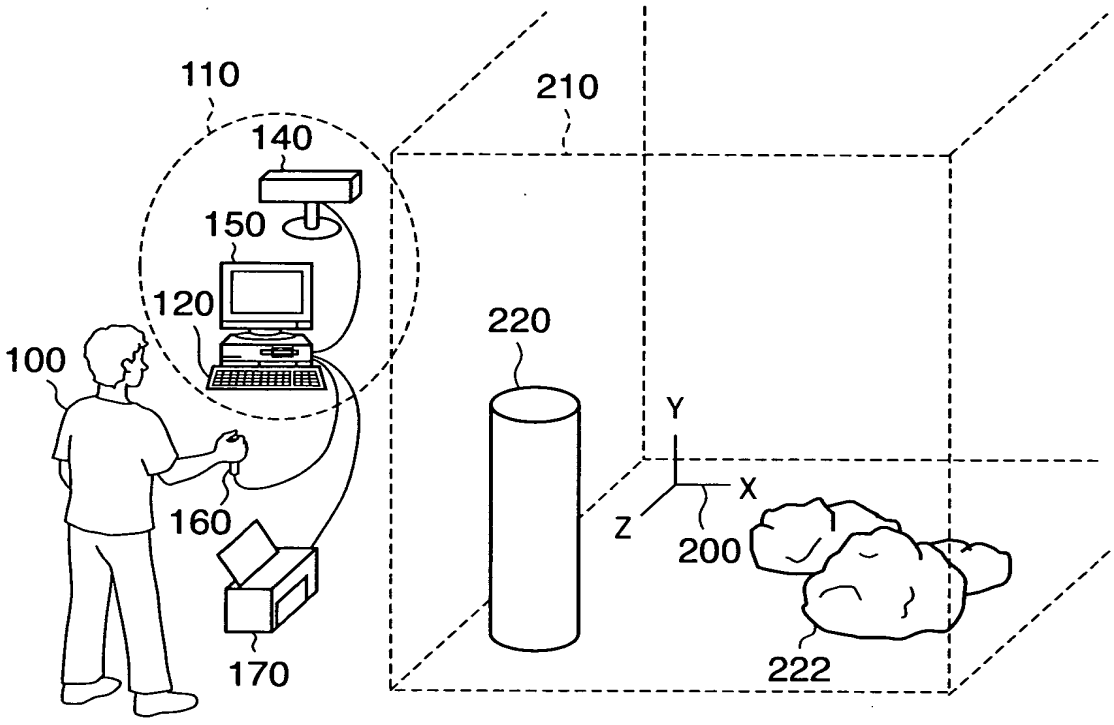

FIG. 2

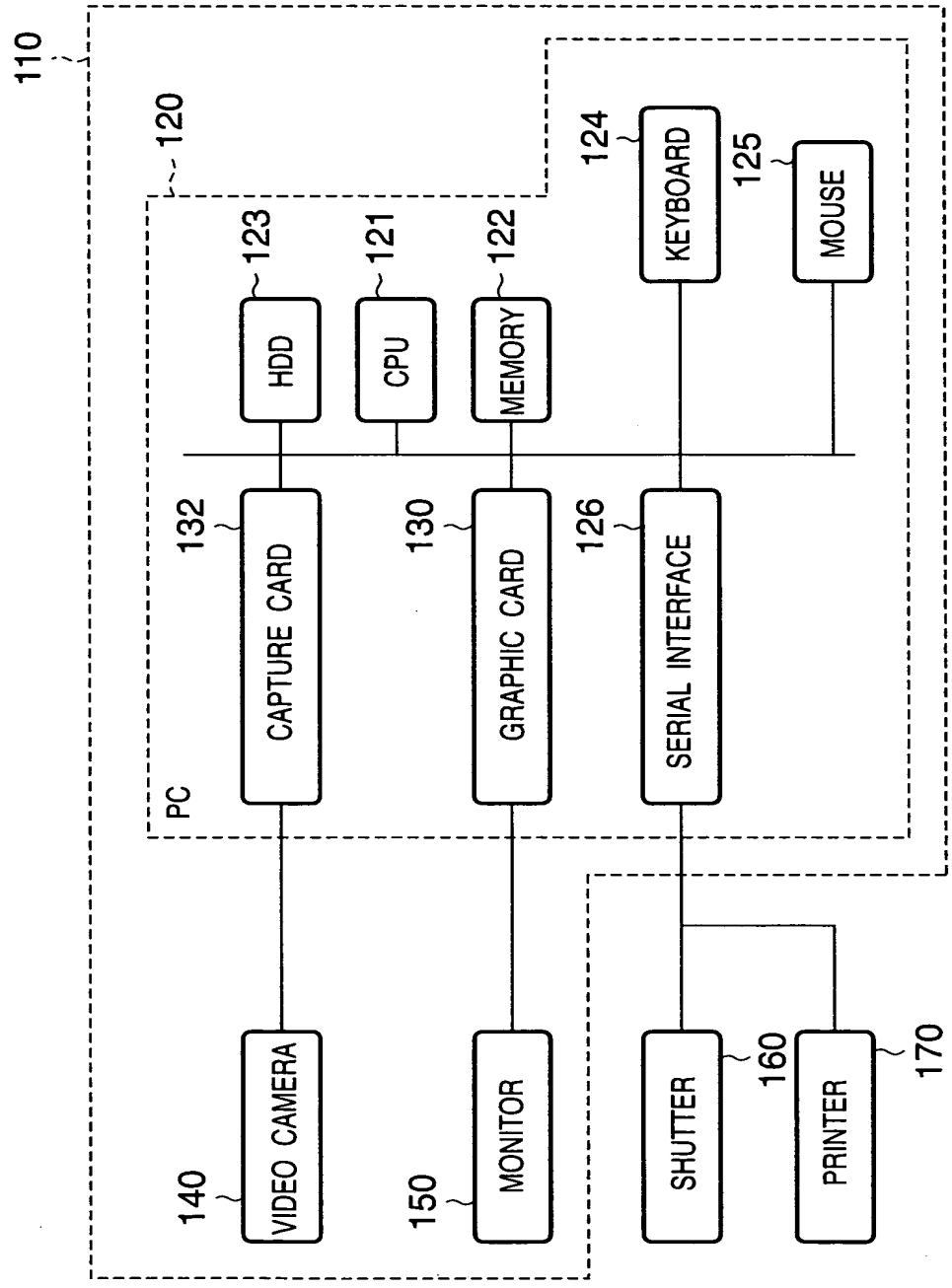
110
120
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
CAPTURE CARD
132
GRAPHIC CARD
130
SERIAL INTERFACE
126
VIDEO CAMERA
140
MONITOR
150
SHUTTER
160
PRINTER
170

FIG. 3

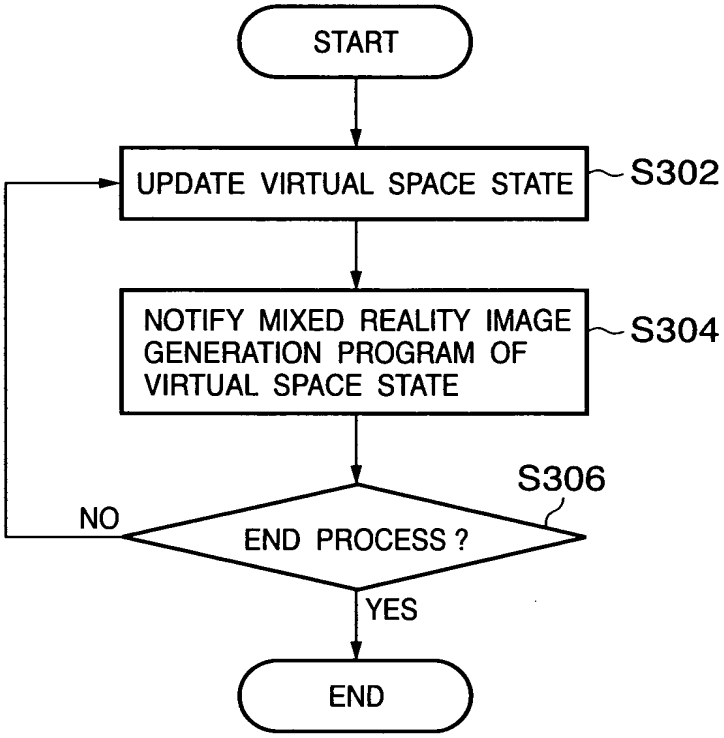
START
UPDATE VIRTUAL SPACE STATE
S302
NOTIFY MIXED REALITY IMAGE GENERATION PROGRAM OF VIRTUAL SPACE STATE
S304
S306
END PROCESS ?
NO
YES
END

FIG. 4

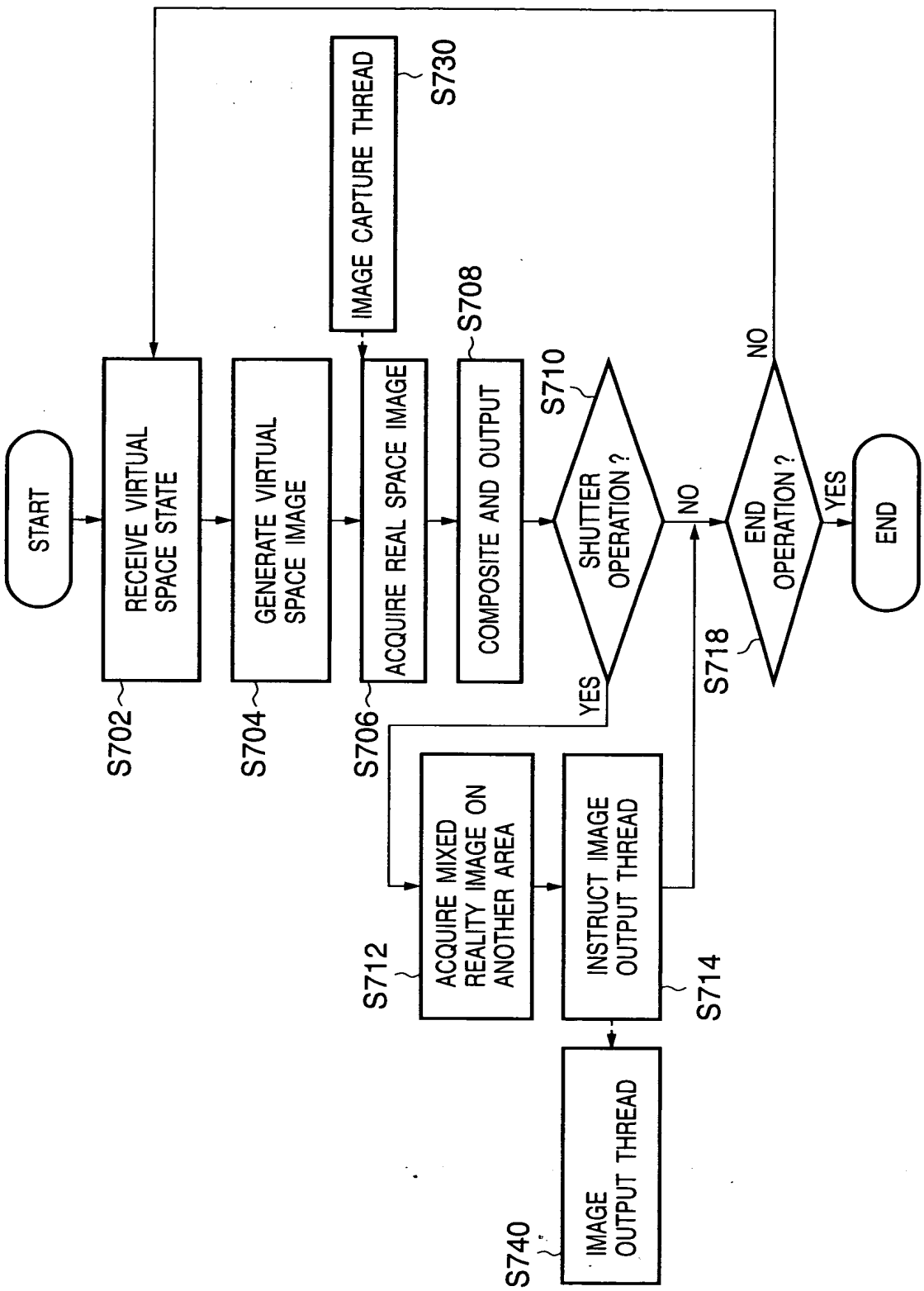
START
RECEIVE VIRTUAL SPACE STATE
S702
GENERATE VIRTUAL SPACE IMAGE
S704
ACQUIRE REAL SPACE IMAGE
S706
IMAGE CAPTURE THREAD
S730
COMPOSITE AND OUTPUT
S708
SHUTTER OPERATION ?
S710
YES
NO
ACQUIRE MIXED REALITY IMAGE ON ANOTHER AREA
S712
INSTRUCT IMAGE OUTPUT THREAD
S714
END OPERATION ?
S718
NO
YES
END
IMAGE OUTPUT THREAD
S740

FIG. 5

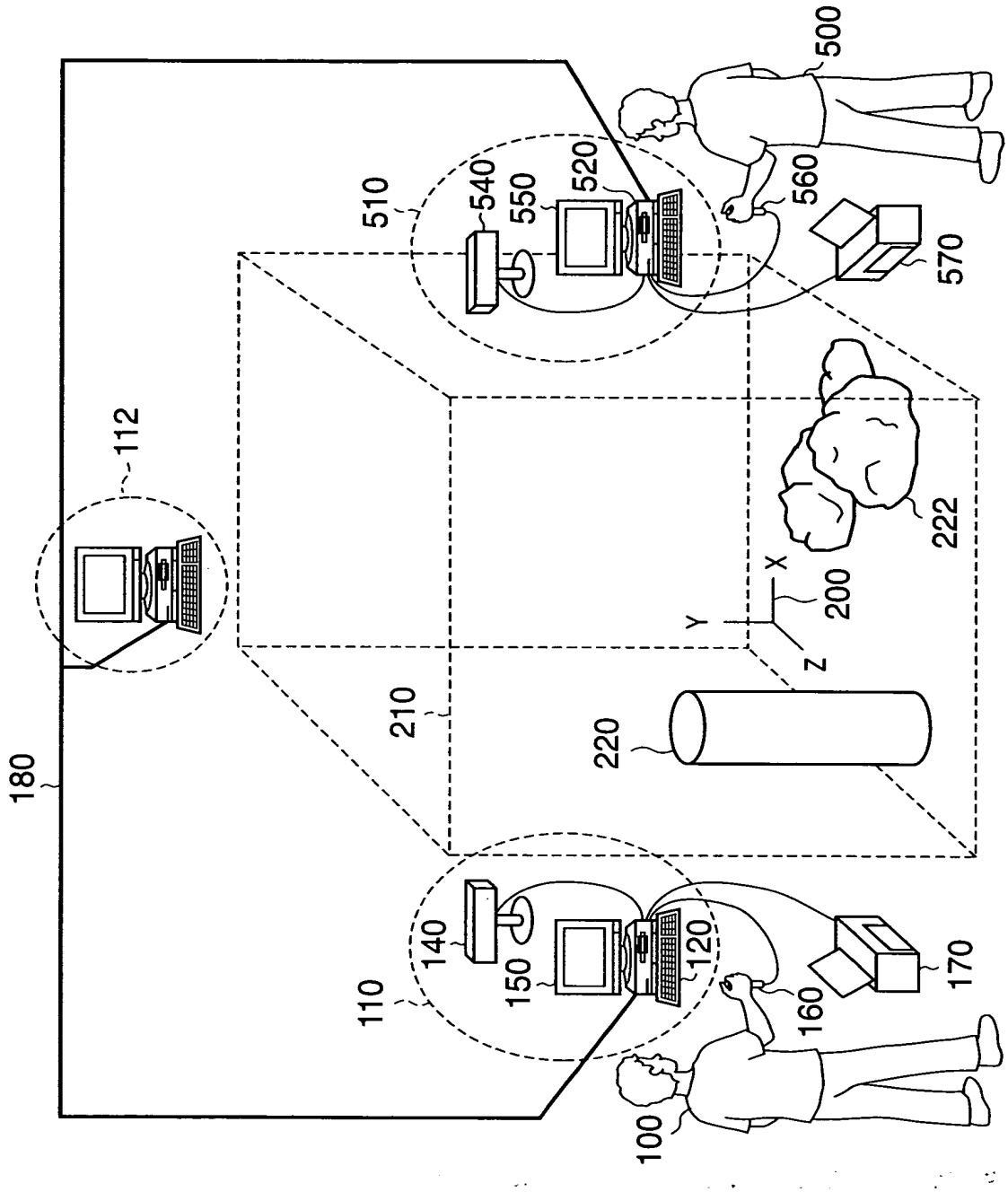
500
510
540
550
520
560
570
112
222
X
200
Y
Z
210
220
180
140
150
120
160
170
110
100

FIG. 6

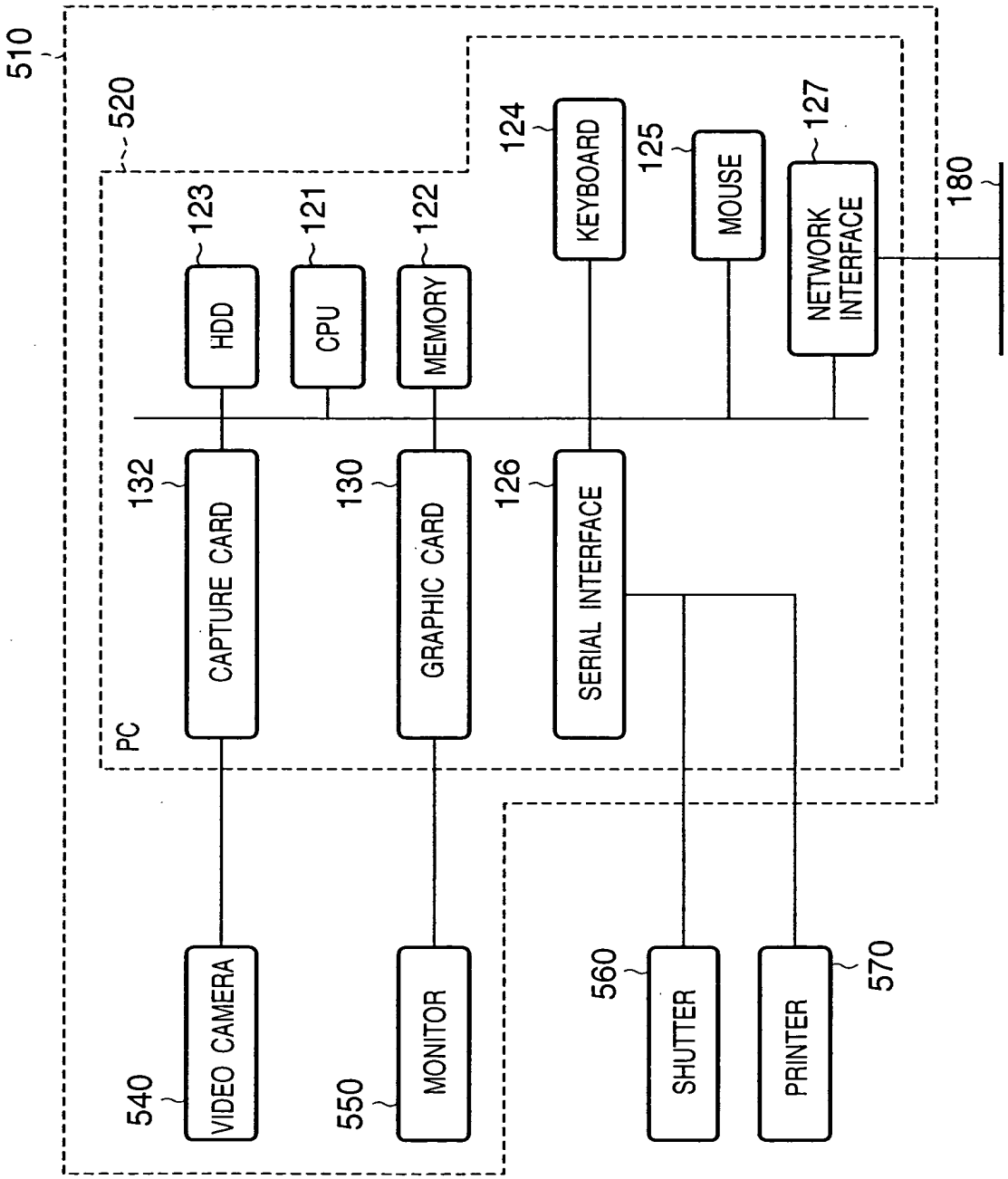
510
520
PC
123
HDD
121
CPU
122
MEMORY
124
KEYBOARD
125
MOUSE
127
NETWORK INTERFACE
180
132
CAPTURE CARD
130
GRAPHIC CARD
126
SERIAL INTERFACE
540
VIDEO CAMERA
550
MONITOR
560
SHUTTER
570
PRINTER

FIG. 7

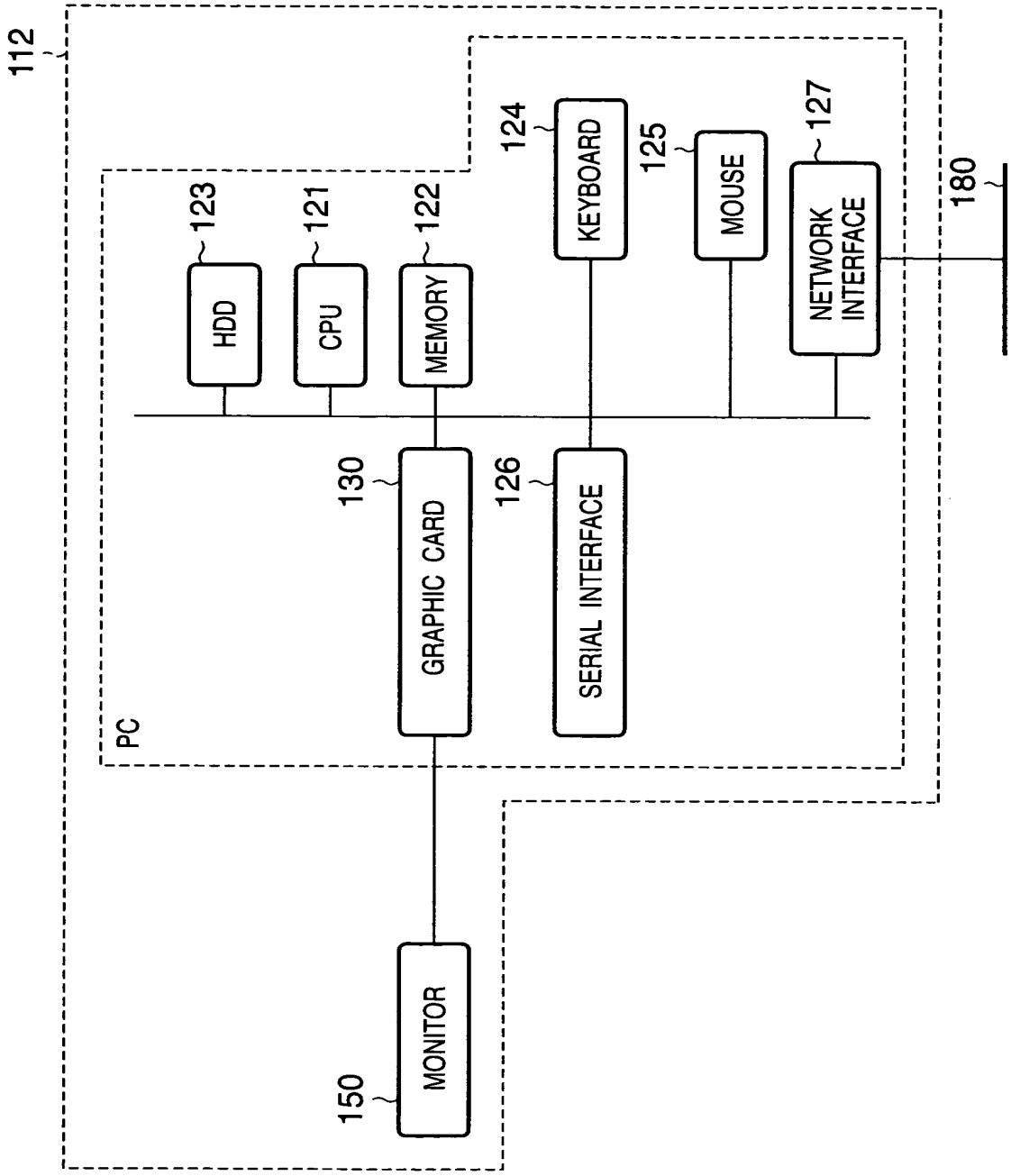
112
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
GRAPHIC CARD
130
SERIAL INTERFACE
126
MONITOR
150

FIG. 8

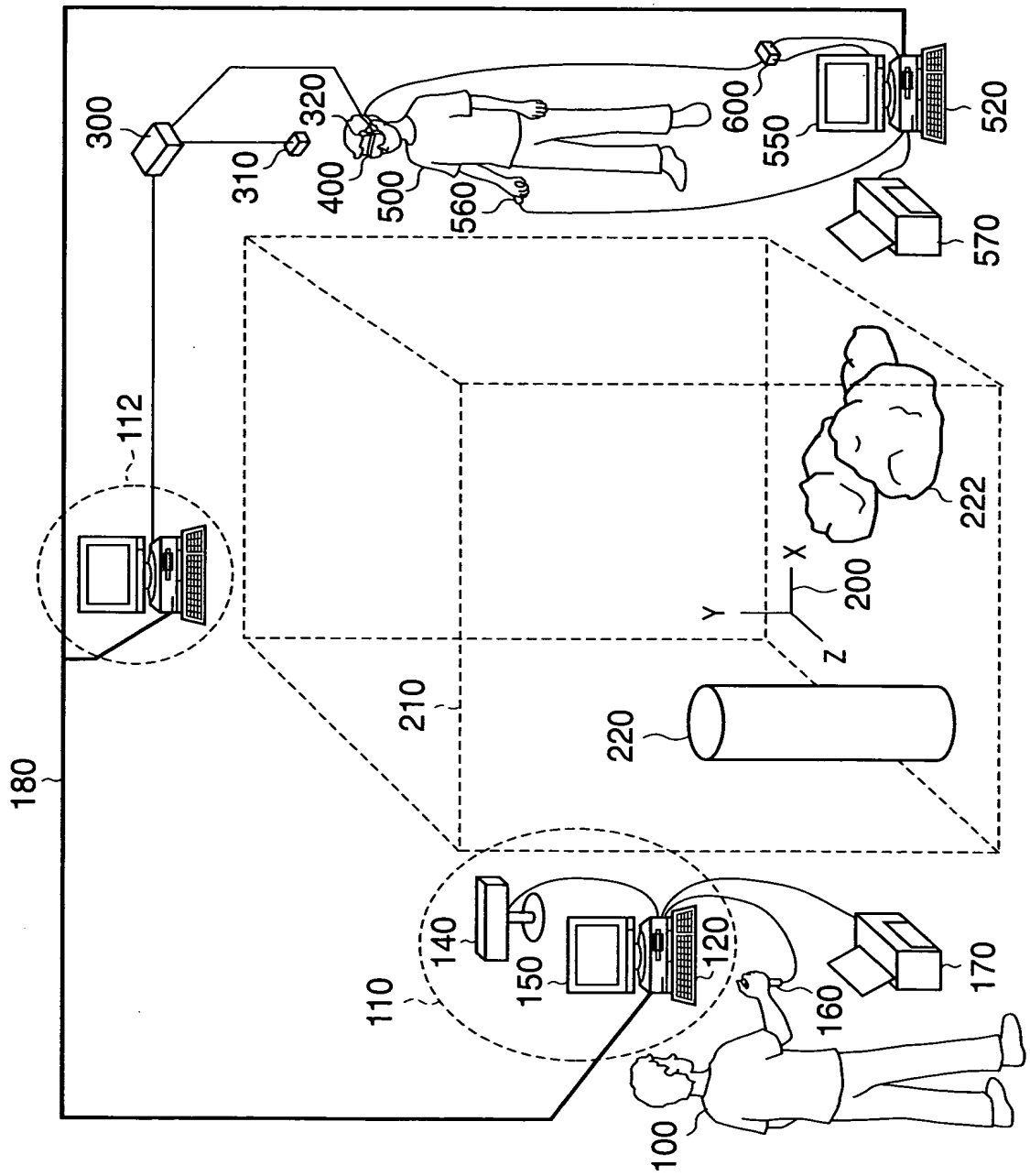
300
310
320
400
500
560
600
550
520
570
112
222
X
200
Y
Z
210
220
180
140
150
120
110
160
170
100

FIG. 9

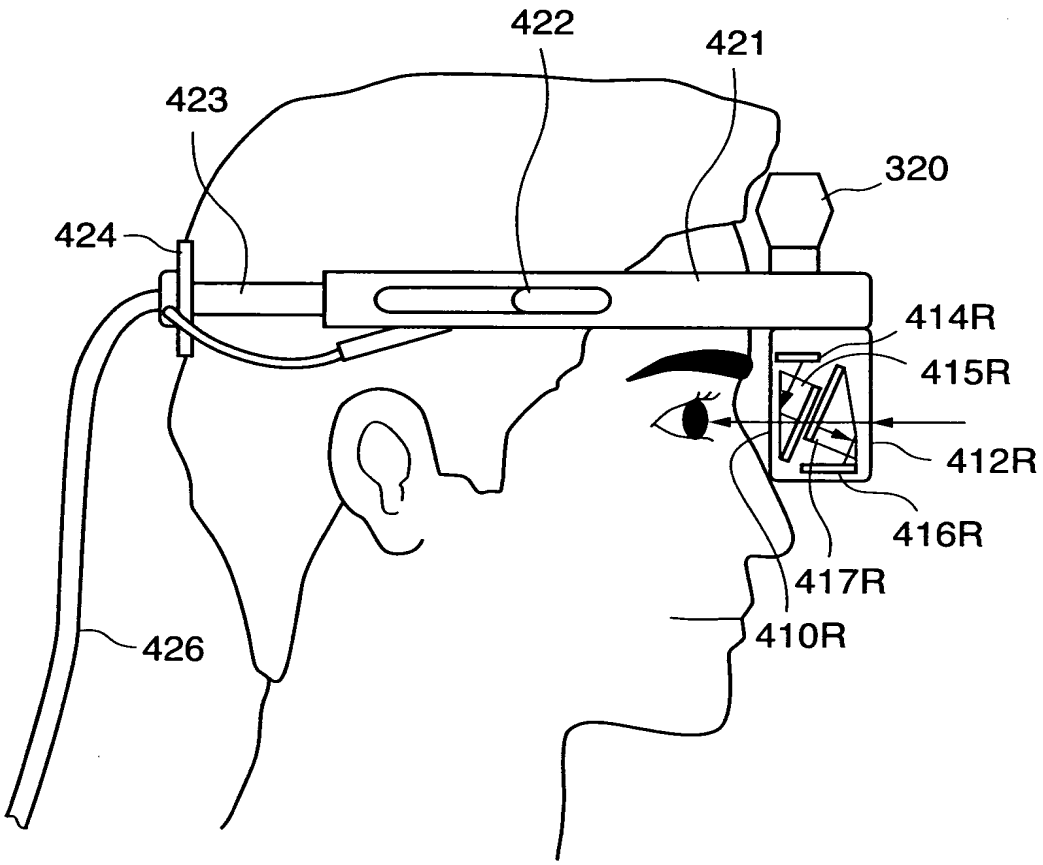

FIG. 10

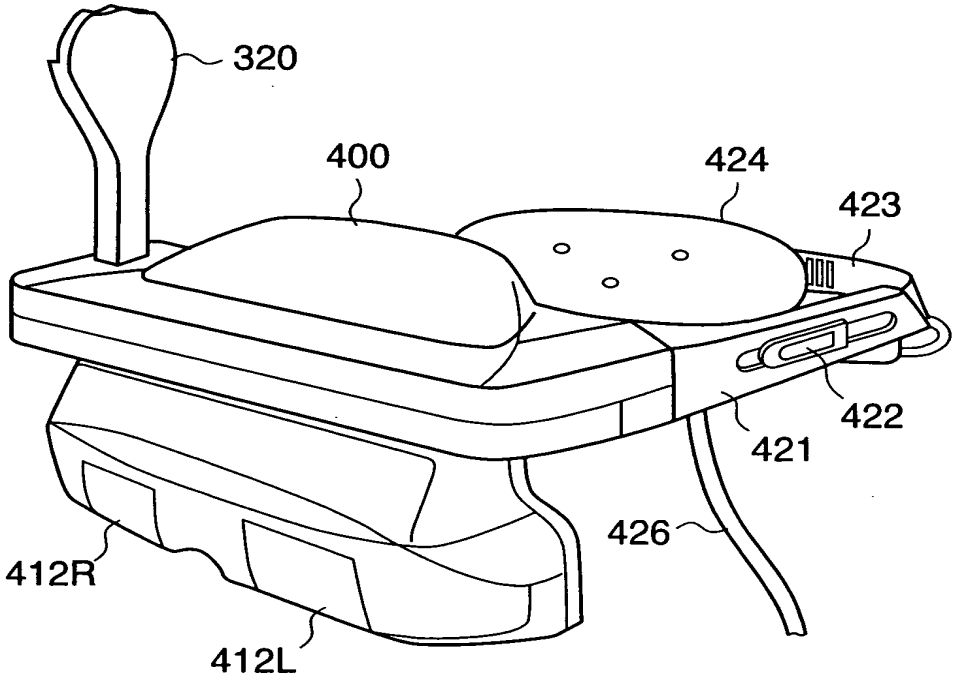

FIG. 11

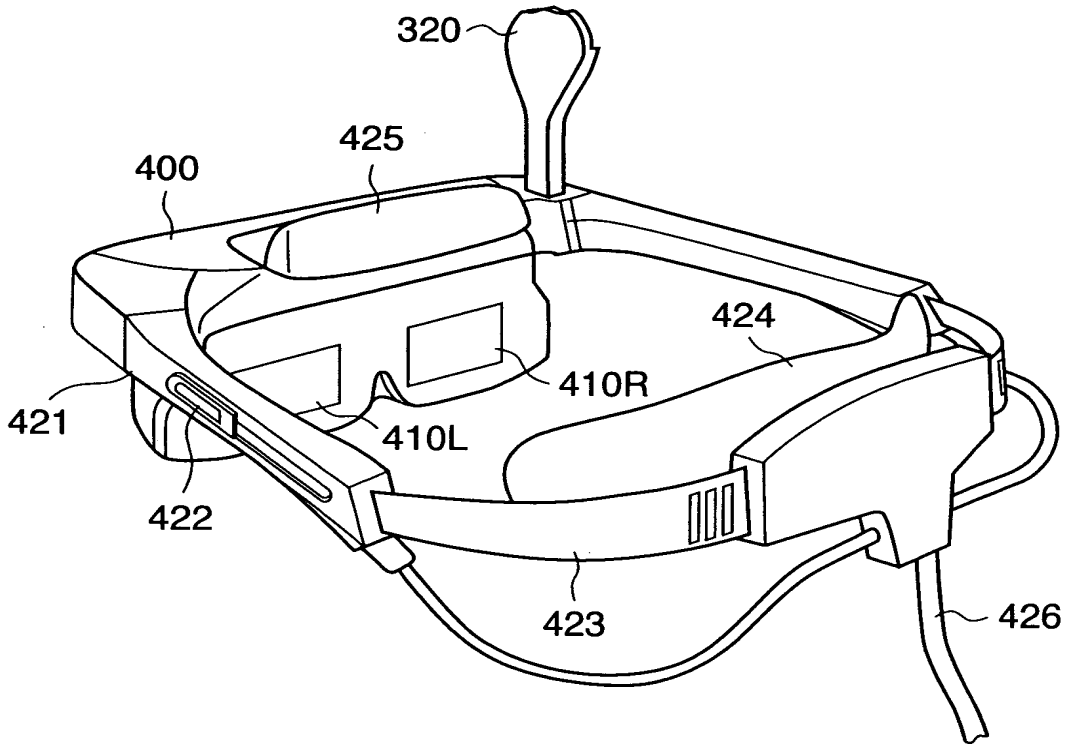

FIG. 12

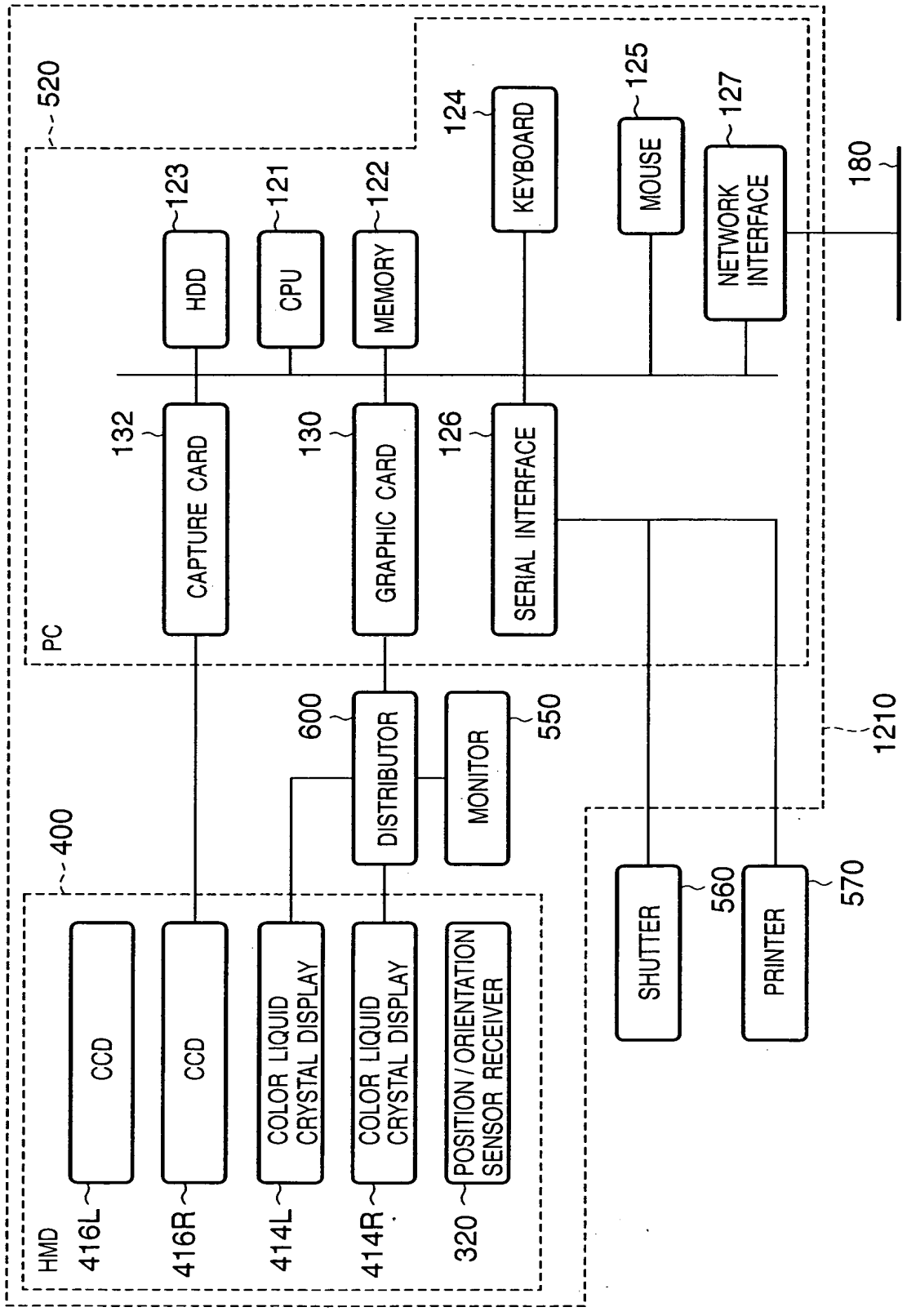
520
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
CAPTURE CARD
132
GRAPHIC CARD
130
SERIAL INTERFACE
126
DISTRIBUTOR
600
MONITOR
550
1210
400
HMD
CCD
416L
CCD
416R
COLOR LIQUID CRYSTAL DISPLAY
414L
COLOR LIQUID CRYSTAL DISPLAY
414R
POSITION / ORIENTATION SENSOR RECEIVER
320
SHUTTER
560
PRINTER
570

FIG. 13

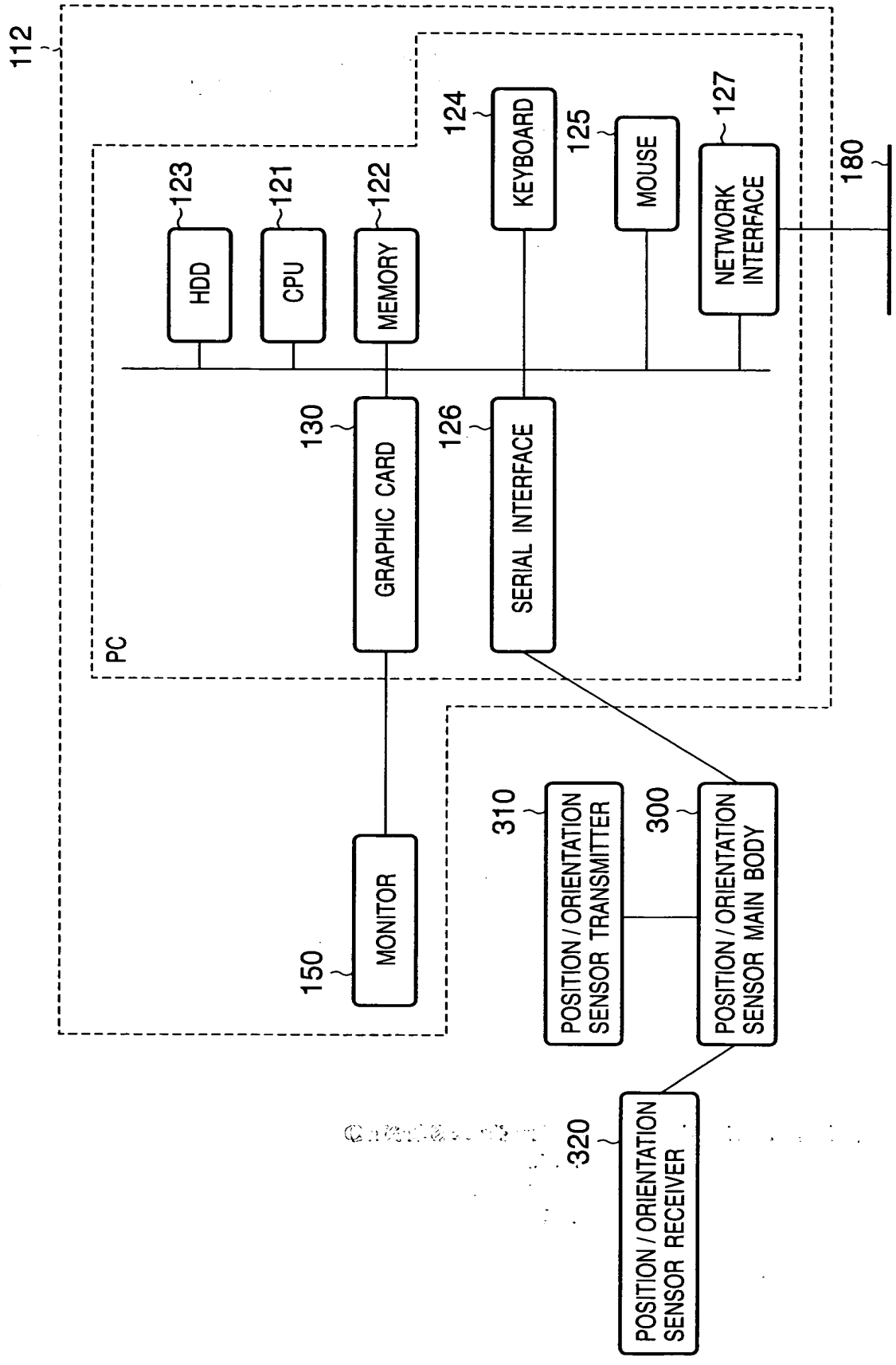
112
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
GRAPHIC CARD
130
SERIAL INTERFACE
126
MONITOR
150
POSITION / ORIENTATION SENSOR TRANSMITTER
310
POSITION / ORIENTATION SENSOR MAIN BODY
300
POSITION / ORIENTATION SENSOR RECEIVER
320

FIG. 14

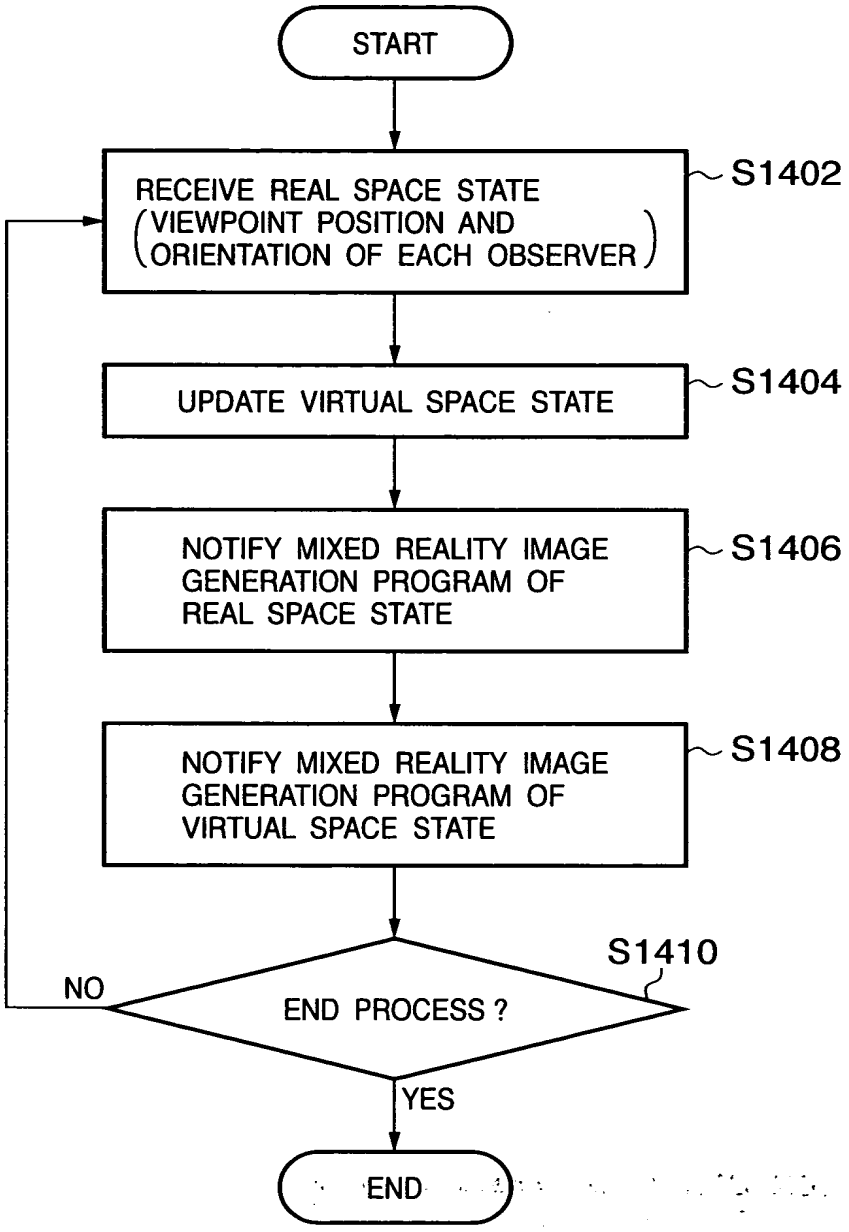
START
RECEIVE REAL SPACE STATE (VIEWPOINT POSITION AND ORIENTATION OF EACH OBSERVER)
S1402
UPDATE VIRTUAL SPACE STATE
S1404
NOTIFY MIXED REALITY IMAGE GENERATION PROGRAM OF REAL SPACE STATE
S1406
NOTIFY MIXED REALITY IMAGE GENERATION PROGRAM OF VIRTUAL SPACE STATE
S1408
S1410
END PROCESS ?
NO
YES
END

FIG. 15

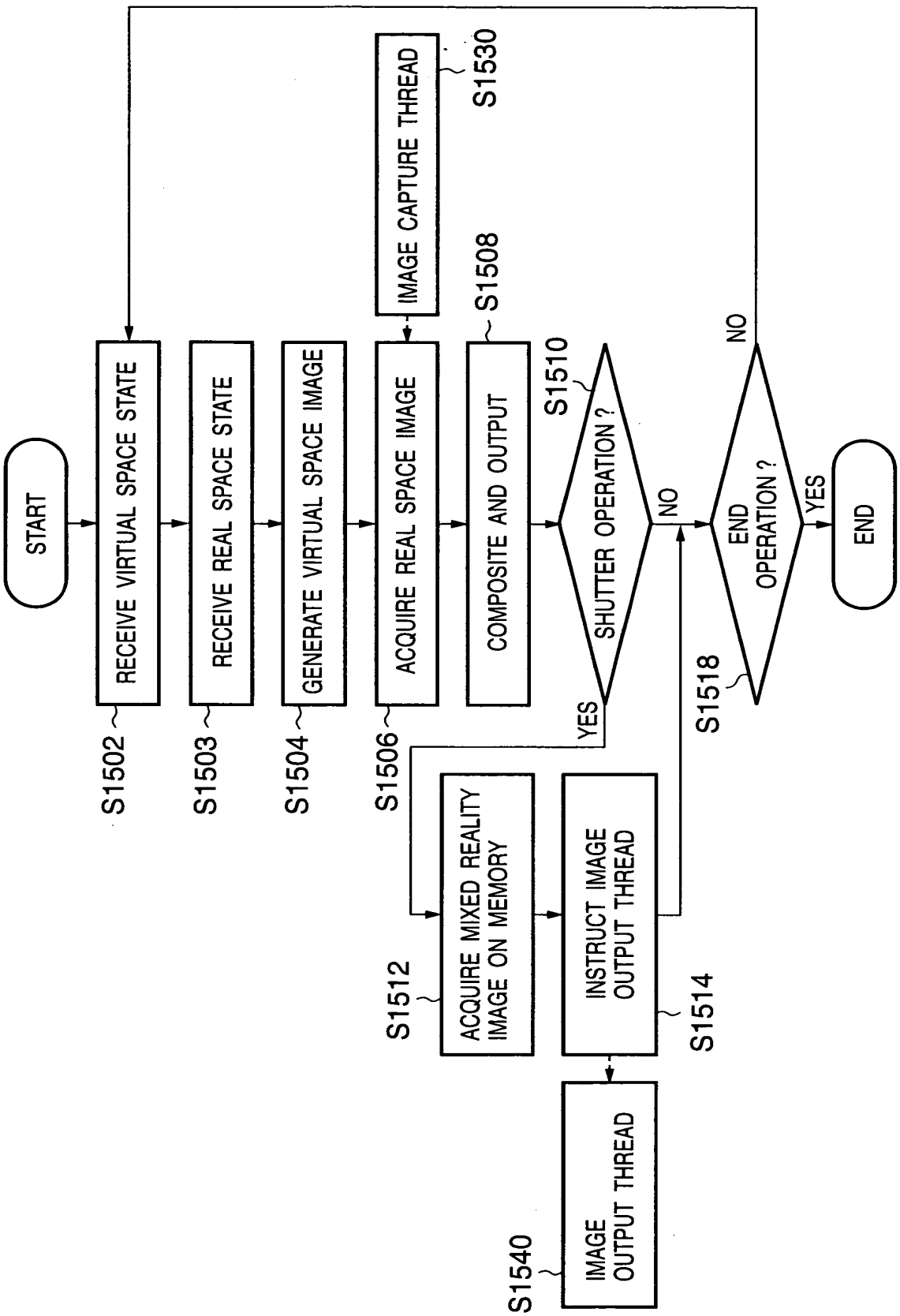
START
RECEIVE VIRTUAL SPACE STATE
S1502
RECEIVE REAL SPACE STATE
S1503
GENERATE VIRTUAL SPACE IMAGE
S1504
ACQUIRE REAL SPACE IMAGE
S1506
IMAGE CAPTURE THREAD
S1530
COMPOSITE AND OUTPUT
S1508
SHUTTER OPERATION ?
S1510
YES
NO
ACQUIRE MIXED REALITY IMAGE ON MEMORY
S1512
INSTRUCT IMAGE OUTPUT THREAD
S1514
IMAGE OUTPUT THREAD
S1540
END OPERATION ?
S1518
NO
YES
END

FIG. 16

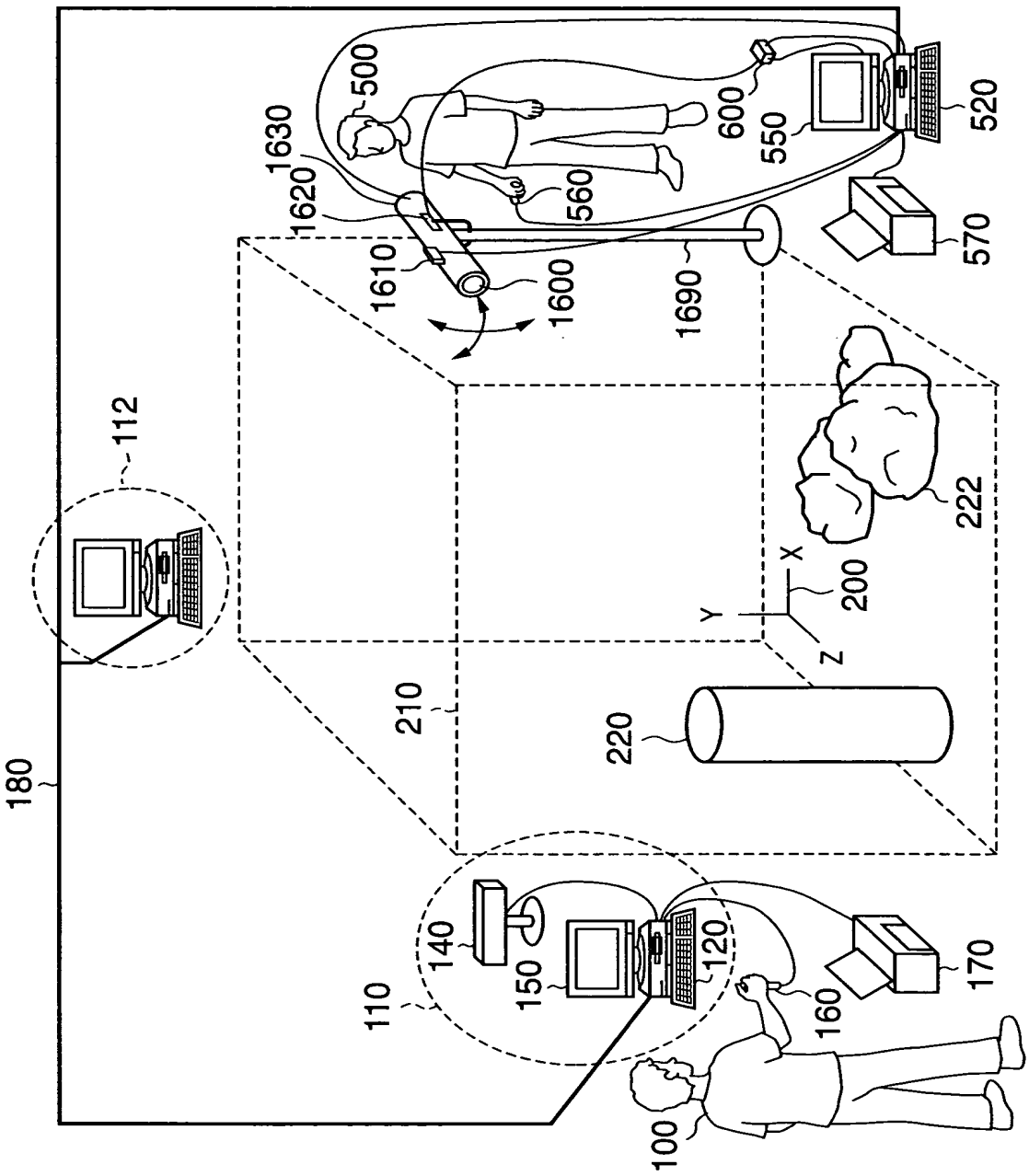
180
112
210
220
222
200
X
Y
Z
500
1630
1620
1610
1600
1690
560
600
550
520
570
140
150
120
110
160
170
100

FIG. 17

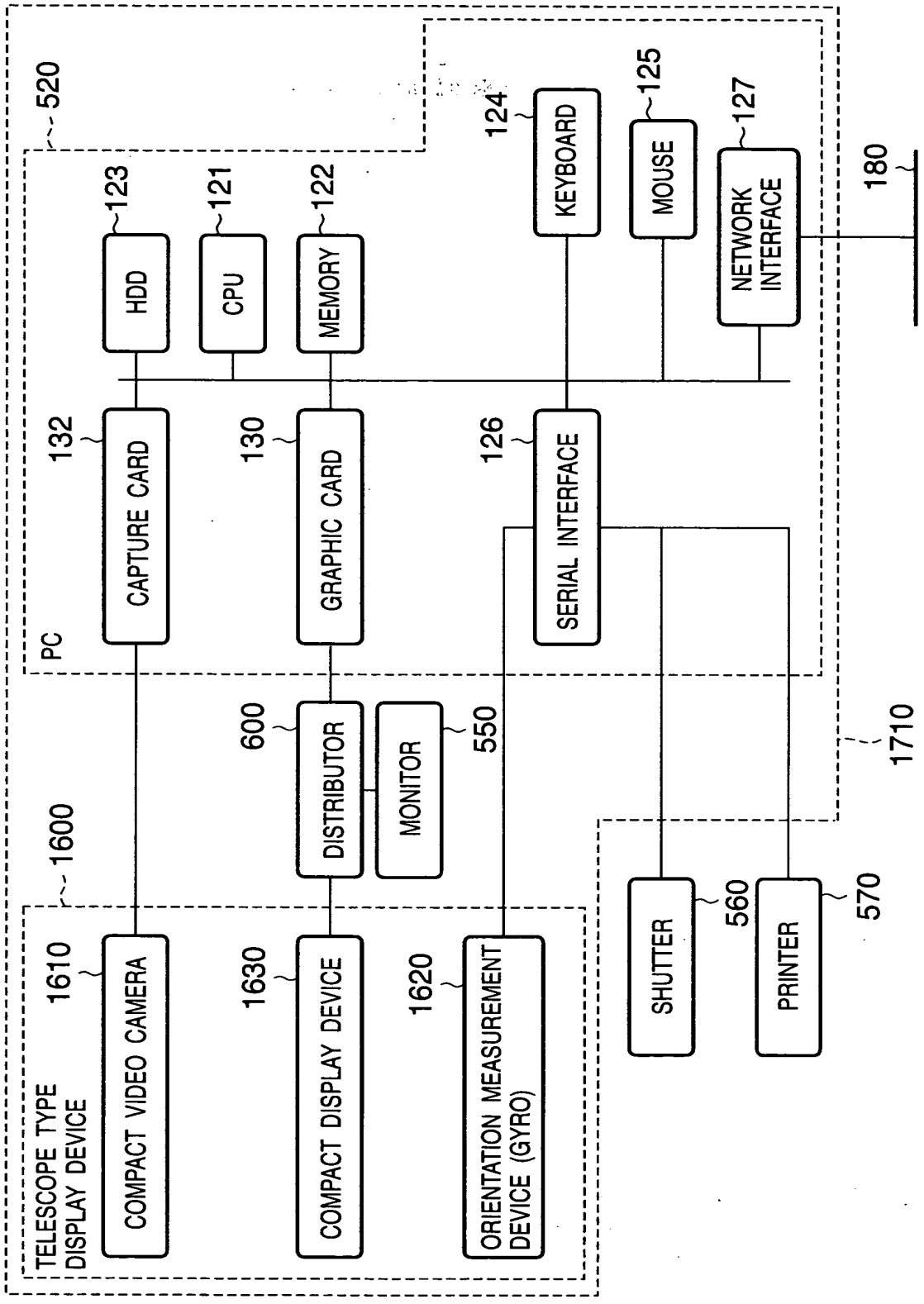
520
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
CAPTURE CARD
132
GRAPHIC CARD
130
SERIAL INTERFACE
126
DISTRIBUTOR
600
MONITOR
550
1710
1600
TELESCOPE TYPE DISPLAY DEVICE
COMPACT VIDEO CAMERA
1610
COMPACT DISPLAY DEVICE
1630
ORIENTATION MEASUREMENT DEVICE (GYRO)
1620
SHUTTER
560
PRINTER
570

FIG. 18

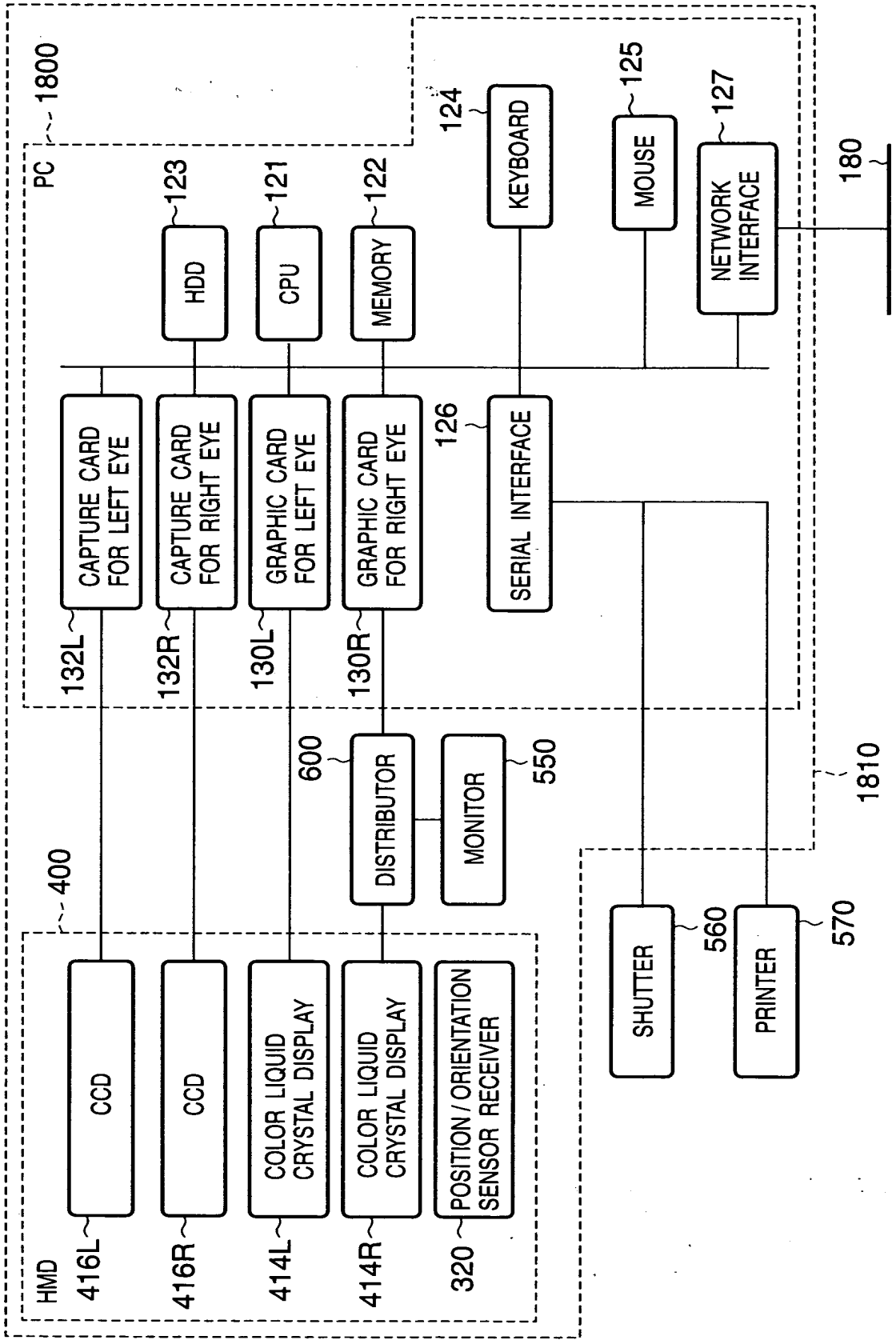
1800
PC
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
CAPTURE CARD FOR LEFT EYE
132L
CAPTURE CARD FOR RIGHT EYE
132R
GRAPHIC CARD FOR LEFT EYE
130L
GRAPHIC CARD FOR RIGHT EYE
130R
SERIAL INTERFACE
126
600
DISTRIBUTOR
MONITOR
550
1810
400
HMD
CCD
416L
CCD
416R
COLOR LIQUID CRYSTAL DISPLAY
414L
COLOR LIQUID CRYSTAL DISPLAY
414R
POSITION / ORIENTATION SENSOR RECEIVER
320
SHUTTER
560
PRINTER
570

FIG. 19

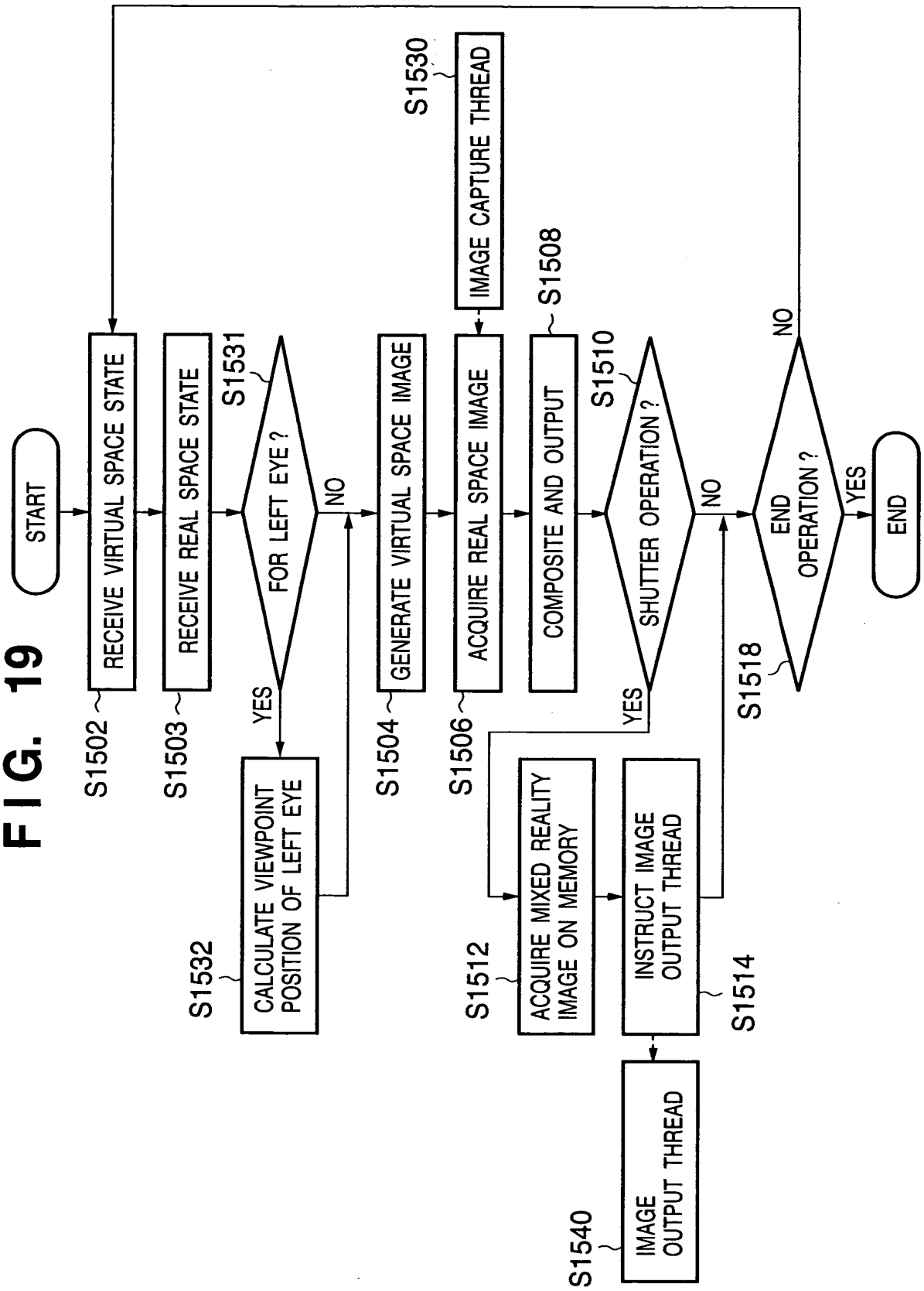
START
RECEIVE VIRTUAL SPACE STATE
S1502
RECEIVE REAL SPACE STATE
S1503
S1531
FOR LEFT EYE ?
YES
NO
S1532
CALCULATE VIEWPOINT POSITION OF LEFT EYE
S1504
GENERATE VIRTUAL SPACE IMAGE
S1530
IMAGE CAPTURE THREAD
S1506
ACQUIRE REAL SPACE IMAGE
S1508
COMPOSITE AND OUTPUT
S1510
SHUTTER OPERATION ?
YES
NO
S1512
ACQUIRE MIXED REALITY IMAGE ON MEMORY
S1514
INSTRUCT IMAGE OUTPUT THREAD
S1518
END OPERATION ?
NO
YES
END
S1540
IMAGE OUTPUT THREAD

FIG. 20

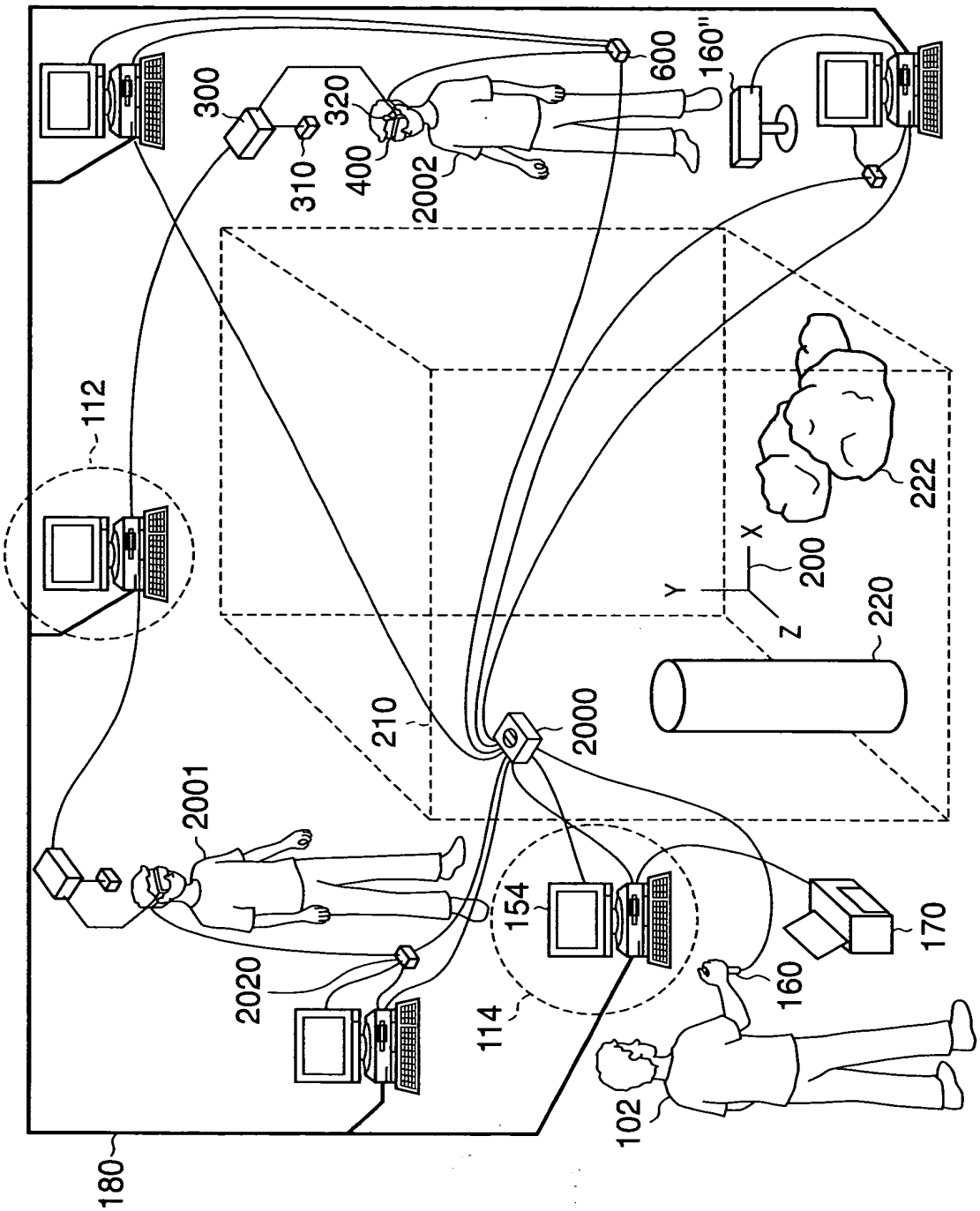
112
300
310
320
400
2002
600
160"
222
X
Y
Z
200
220
210
2000
2001
2020
154
114
160
170
102
180

FIG. 21

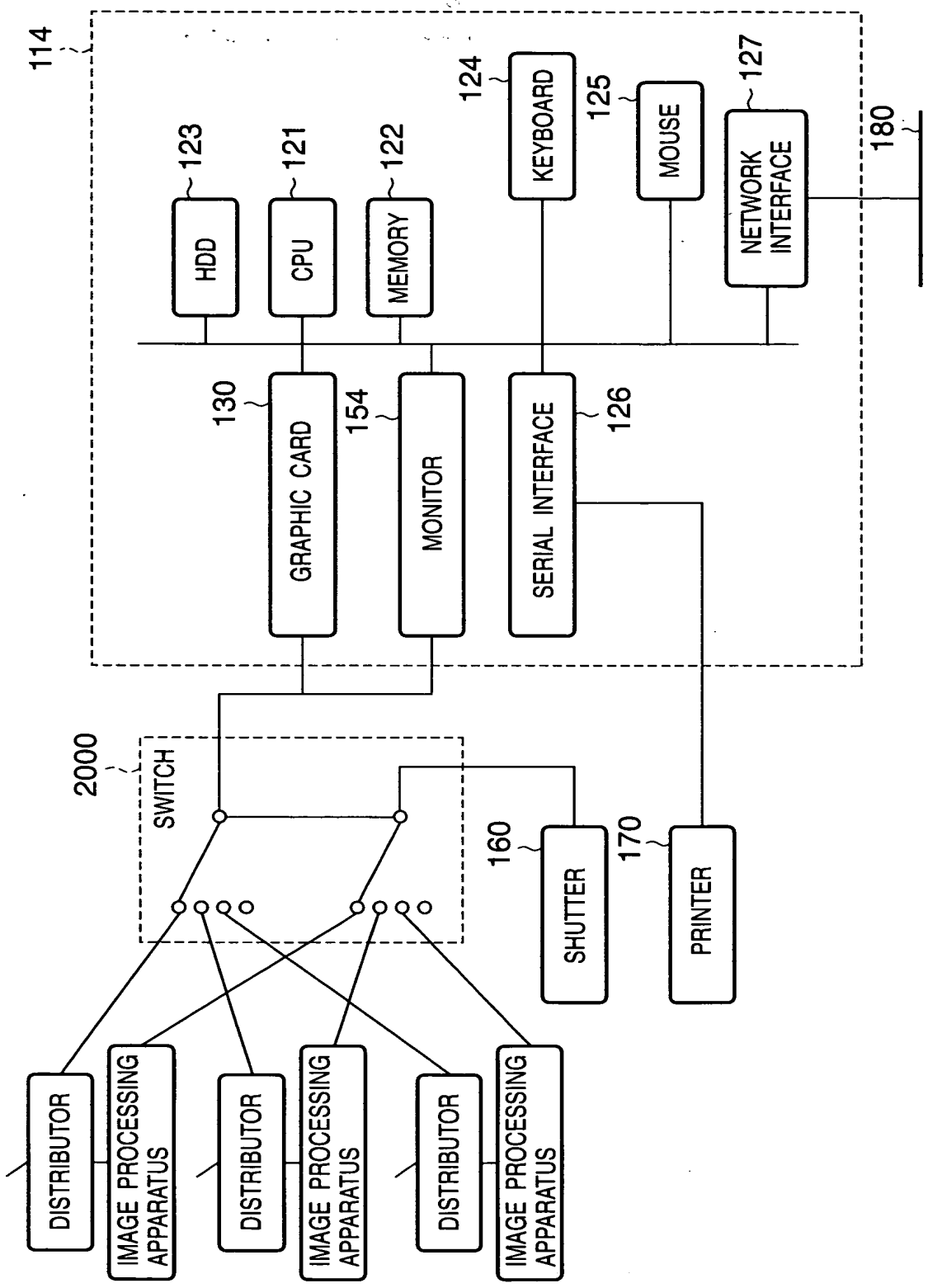
114
HDD
123
CPU
121
MEMORY
122
KEYBOARD
124
MOUSE
125
NETWORK INTERFACE
127
180
GRAPHIC CARD
130
MONITOR
154
SERIAL INTERFACE
126
2000
SWITCH
SHUTTER
160
PRINTER
170
DISTRIBUTOR
IMAGE PROCESSING APPARATUS
DISTRIBUTOR
IMAGE PROCESSING APPARATUS
DISTRIBUTOR
IMAGE PROCESSING APPARATUS

FIG. 22

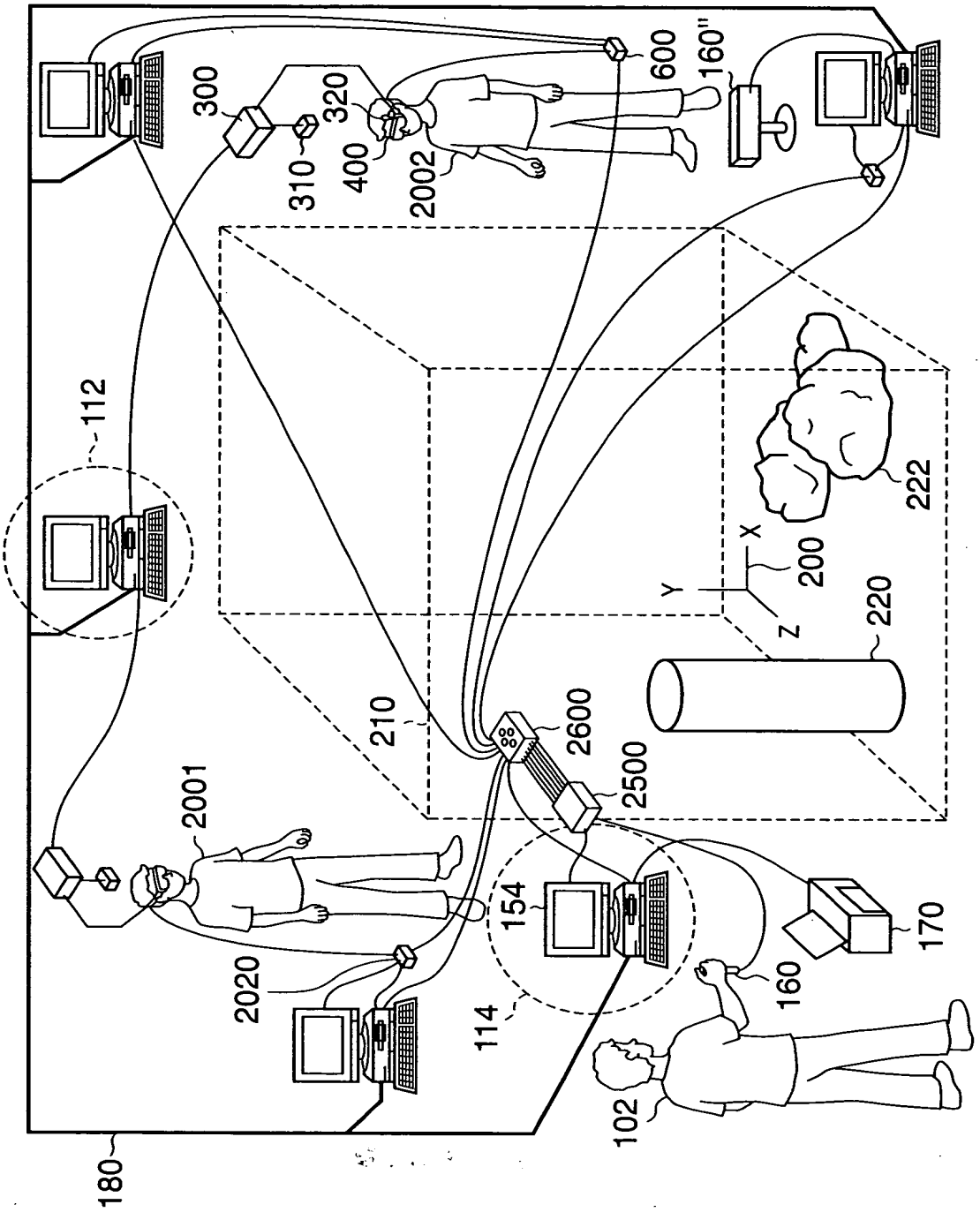
180
102
160
170
154
114
2020
2001
210
2600
2500
220
222
X
Y
Z
200
112
2002
310
300
320
400
600
160''

FIG. 23

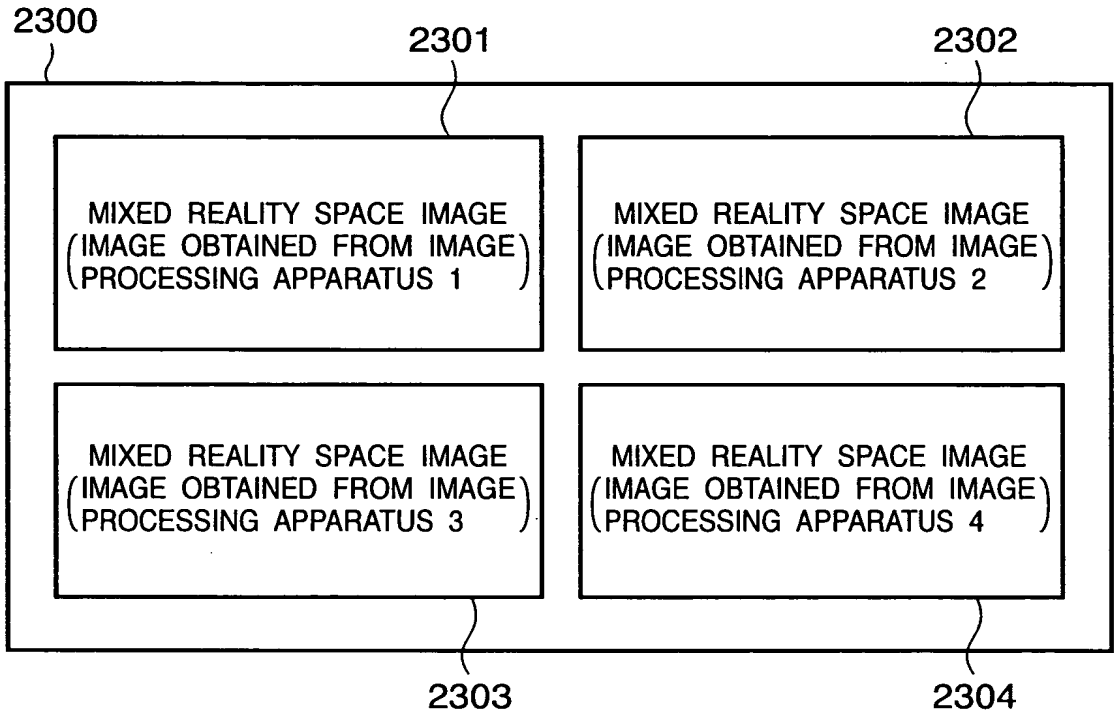
2300
2301
2302
MIXED REALITY SPACE IMAGE (IMAGE OBTAINED FROM IMAGE PROCESSING APPARATUS 1
MIXED REALITY SPACE IMAGE (IMAGE OBTAINED FROM IMAGE PROCESSING APPARATUS 2
MIXED REALITY SPACE IMAGE (IMAGE OBTAINED FROM IMAGE PROCESSING APPARATUS 3
MIXED REALITY SPACE IMAGE (IMAGE OBTAINED FROM IMAGE PROCESSING APPARATUS 4
2303
2304

FIG. 24

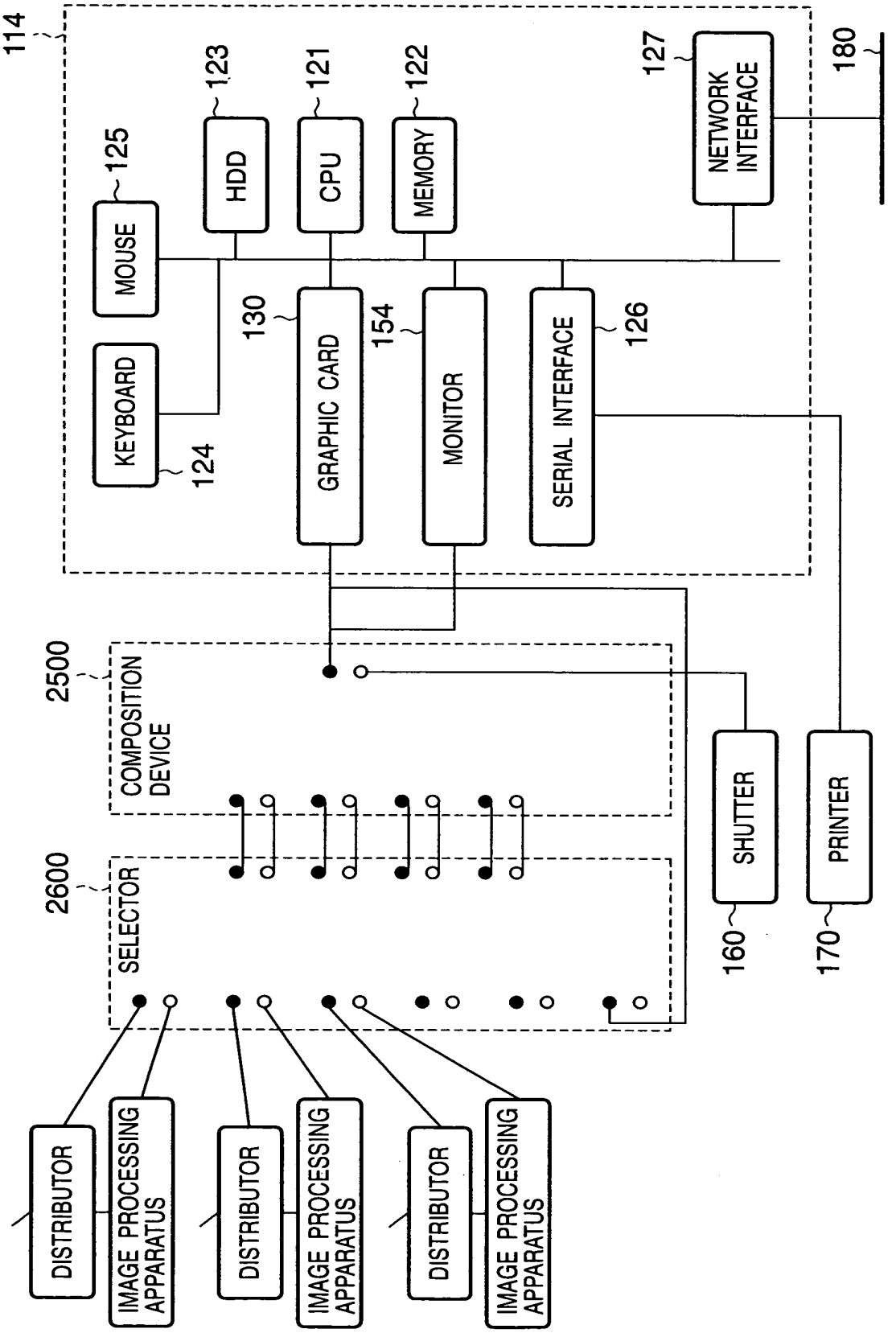
114
123
HDD
121
CPU
122
MEMORY
127
NETWORK INTERFACE
180
125
MOUSE
KEYBOARD
124
130
GRAPHIC CARD
154
MONITOR
SERIAL INTERFACE
126
2500
COMPOSITION DEVICE
2600
SELECTOR
SHUTTER
160
PRINTER
170
DISTRIBUTOR
IMAGE PROCESSING APPARATUS
DISTRIBUTOR
IMAGE PROCESSING APPARATUS
DISTRIBUTOR
IMAGE PROCESSING APPARATUS

FIG. 25

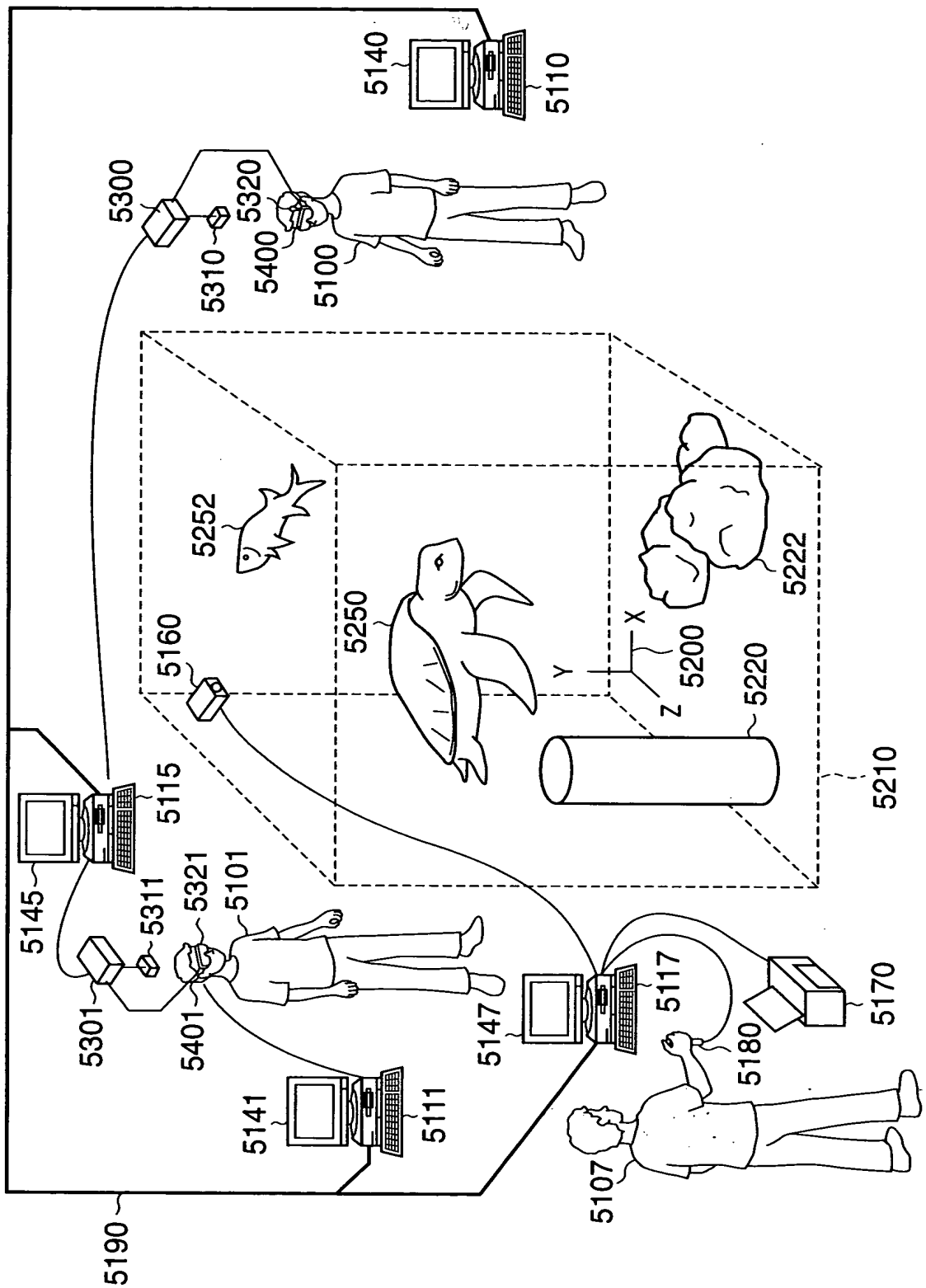
5140
5110
5300
5320
5310
5400
5100
5252
5250
5222
5160
X
Y
Z
5200
5220
5210
5115
5145
5311
5321
5101
5301
5401
5147
5117
5170
5180
5141
5111
5107
5190

FIG. 26

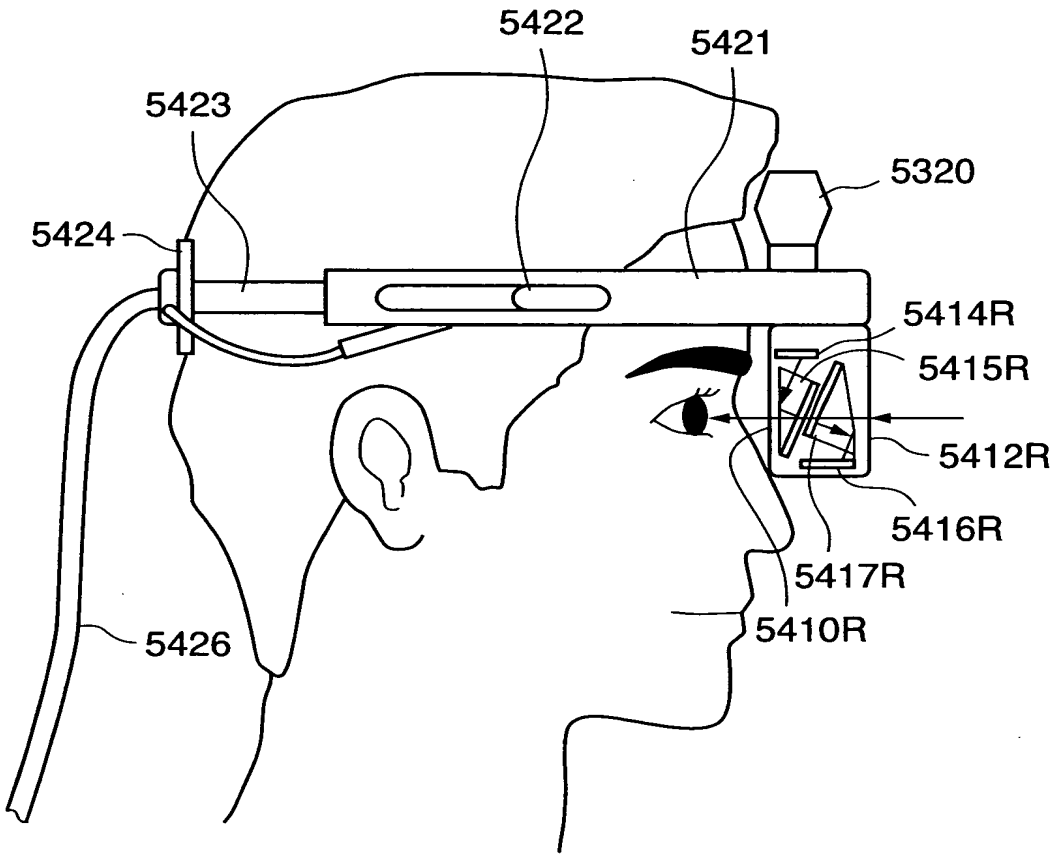
5422
5421
5423
5320
5424
5414R
5415R
5412R
5416R
5417R
5410R
5426

FIG. 27

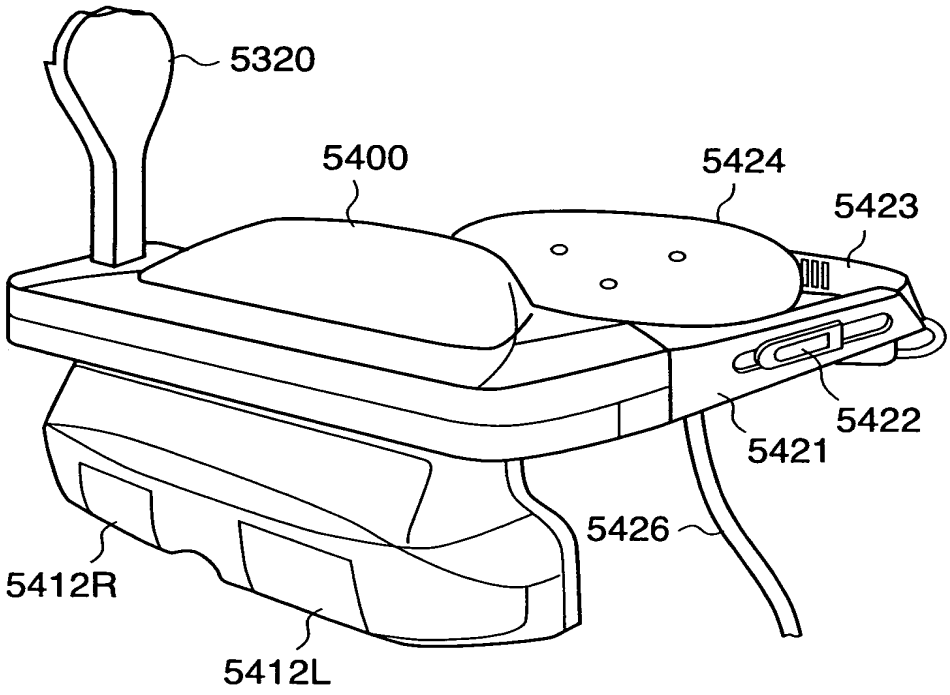

FIG. 28

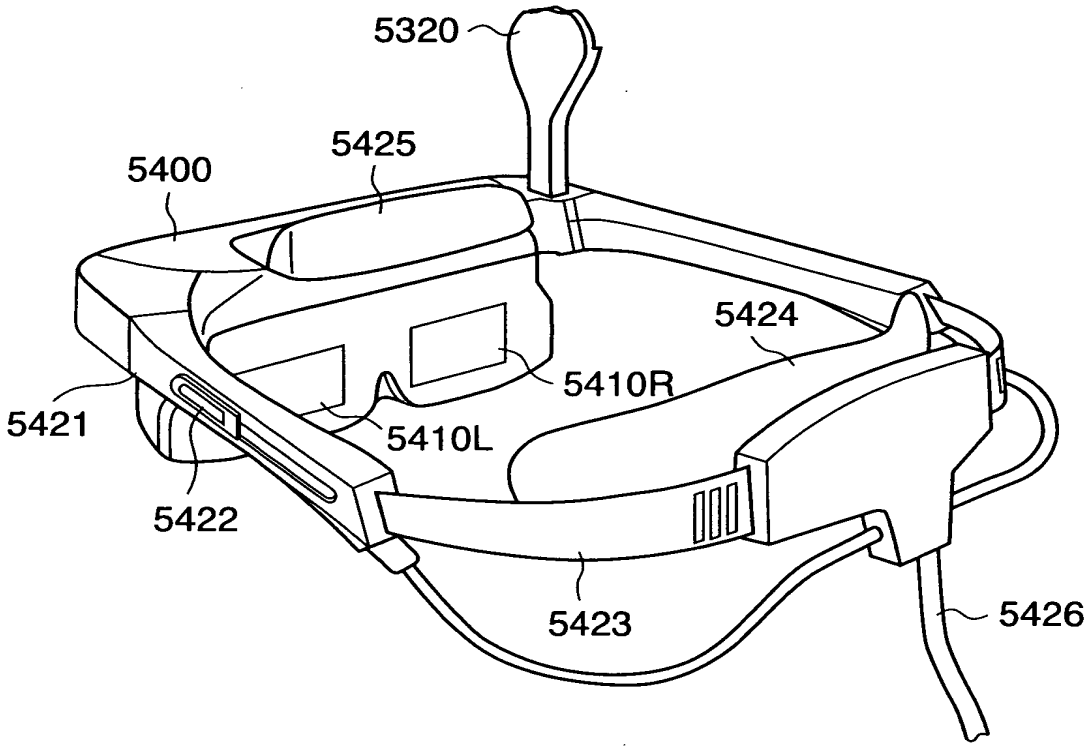

FIG. 29

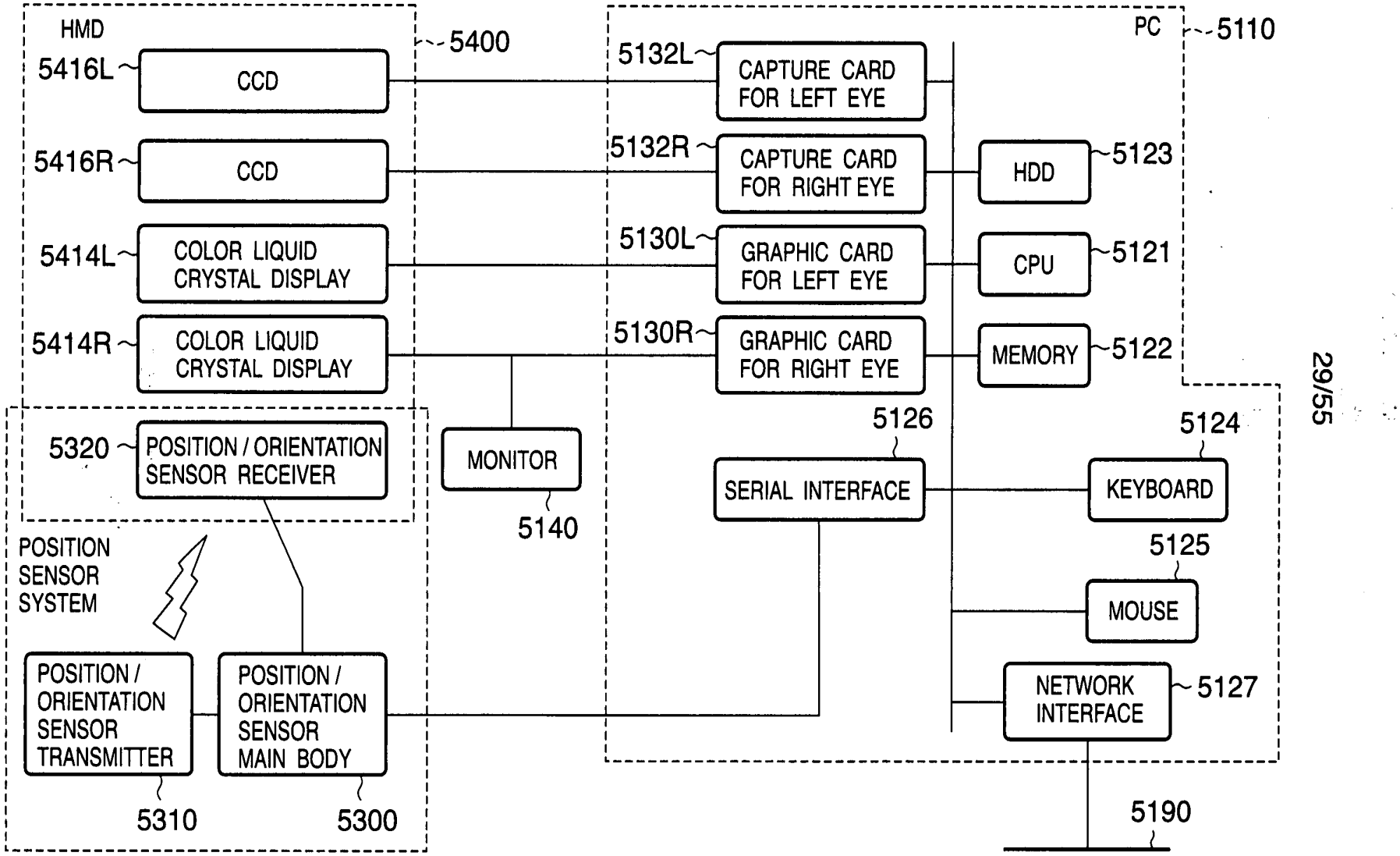
HMD
5400
5416L
CCD
5416R
CCD
5414L
COLOR LIQUID CRYSTAL DISPLAY
5414R
COLOR LIQUID CRYSTAL DISPLAY
5320
POSITION / ORIENTATION SENSOR RECEIVER
MONITOR
5140
POSITION SENSOR SYSTEM
POSITION / ORIENTATION SENSOR TRANSMITTER
5310
POSITION / ORIENTATION SENSOR MAIN BODY
5300
PC
5110
5132L
CAPTURE CARD FOR LEFT EYE
5132R
CAPTURE CARD FOR RIGHT EYE
5130L
GRAPHIC CARD FOR LEFT EYE
5130R
GRAPHIC CARD FOR RIGHT EYE
HDD
5123
CPU
5121
MEMORY
5122
5126
SERIAL INTERFACE
5124
KEYBOARD
5125
MOUSE
NETWORK INTERFACE
5127
5190

FIG. 30

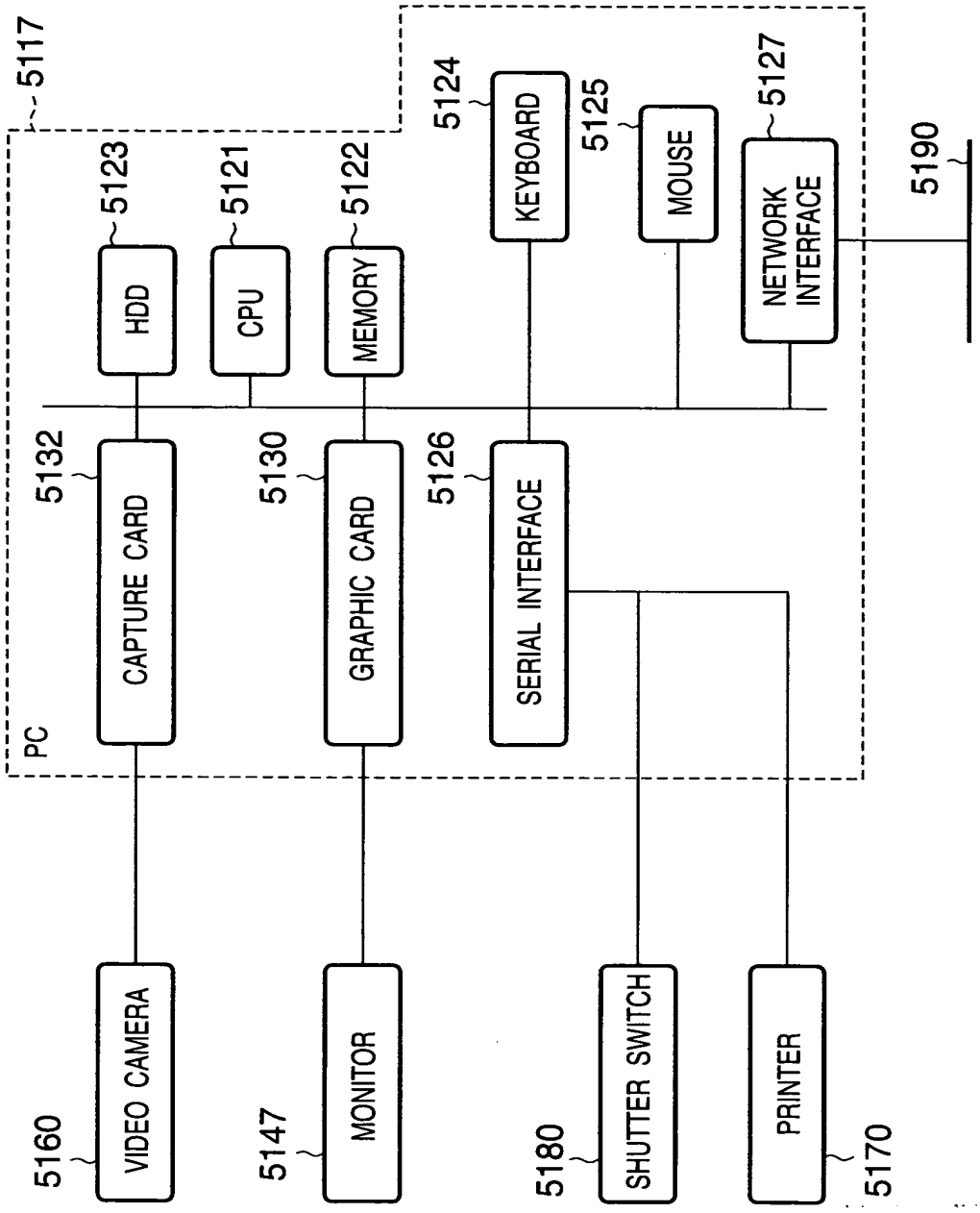
5117
PC
5123
HDD
5121
CPU
5122
MEMORY
5124
KEYBOARD
5125
MOUSE
5127
NETWORK INTERFACE
5190
5132
CAPTURE CARD
5130
GRAPHIC CARD
5126
SERIAL INTERFACE
5160
VIDEO CAMERA
5147
MONITOR
5180
SHUTTER SWITCH
5170
PRINTER

FIG. 31

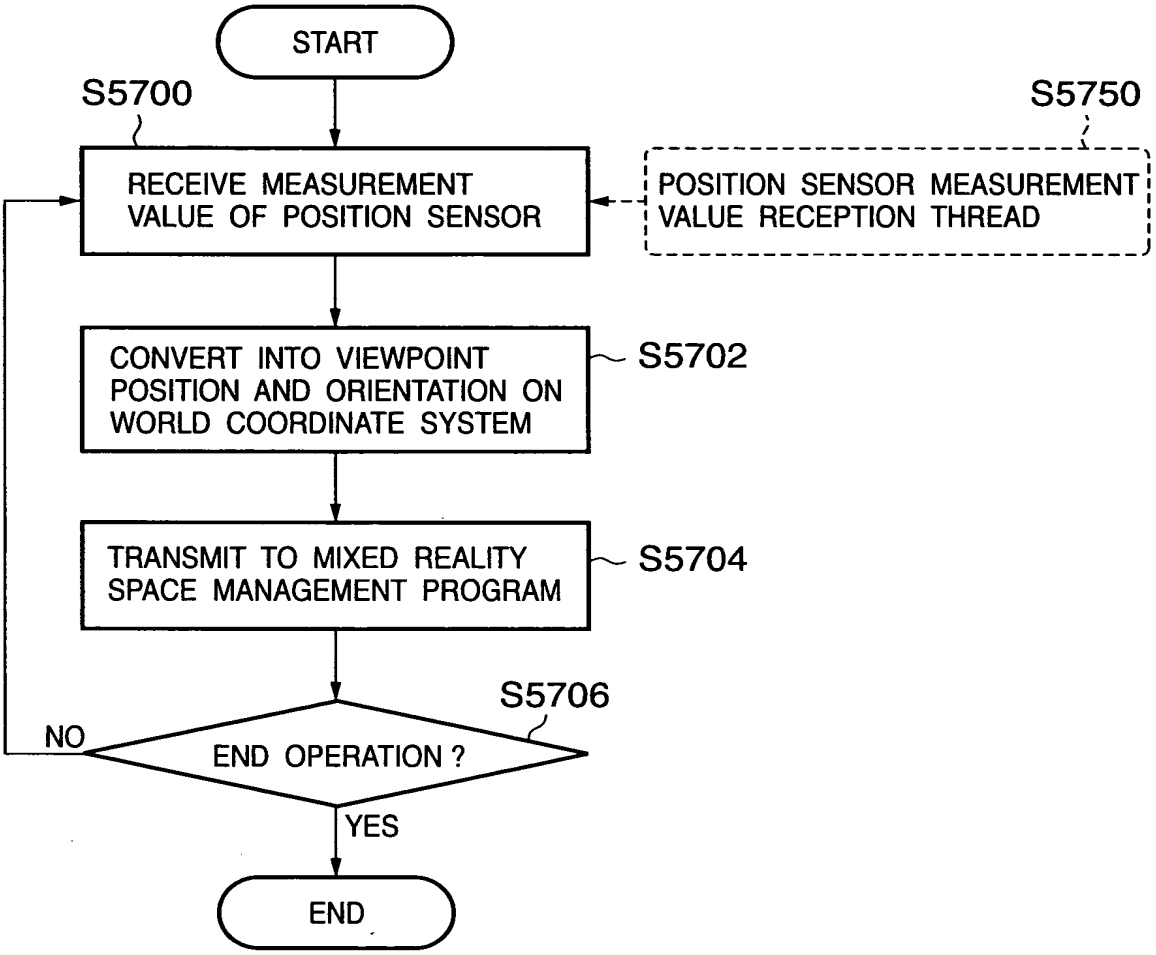
START
S5700
S5750
RECEIVE MEASUREMENT VALUE OF POSITION SENSOR
POSITION SENSOR MEASUREMENT VALUE RECEPTION THREAD
CONVERT INTO VIEWPOINT POSITION AND ORIENTATION ON WORLD COORDINATE SYSTEM
S5702
TRANSMIT TO MIXED REALITY SPACE MANAGEMENT PROGRAM
S5704
S5706
NO
END OPERATION ?
YES
END

FIG. 32

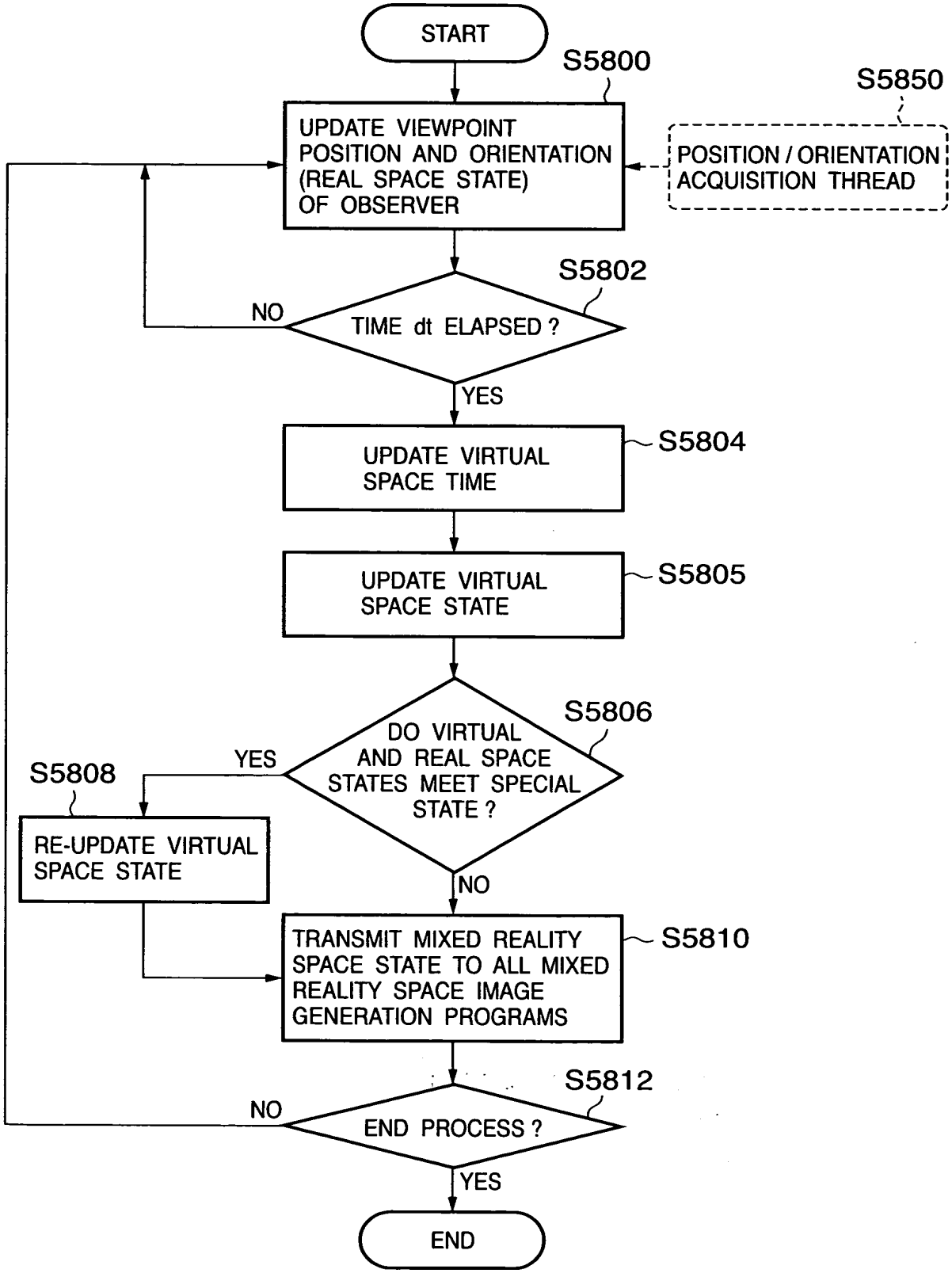
START
S5800
UPDATE VIEWPOINT POSITION AND ORIENTATION (REAL SPACE STATE) OF OBSERVER
S5850
POSITION / ORIENTATION ACQUISITION THREAD
S5802
NO
TIME dt ELAPSED ?
YES
S5804
UPDATE VIRTUAL SPACE TIME
S5805
UPDATE VIRTUAL SPACE STATE
S5806
DO VIRTUAL AND REAL SPACE STATES MEET SPECIAL STATE ?
YES
S5808
RE-UPDATE VIRTUAL SPACE STATE
NO
S5810
TRANSMIT MIXED REALITY SPACE STATE TO ALL MIXED REALITY SPACE IMAGE GENERATION PROGRAMS
S5812
NO
END PROCESS ?
YES
END

FIG. 33

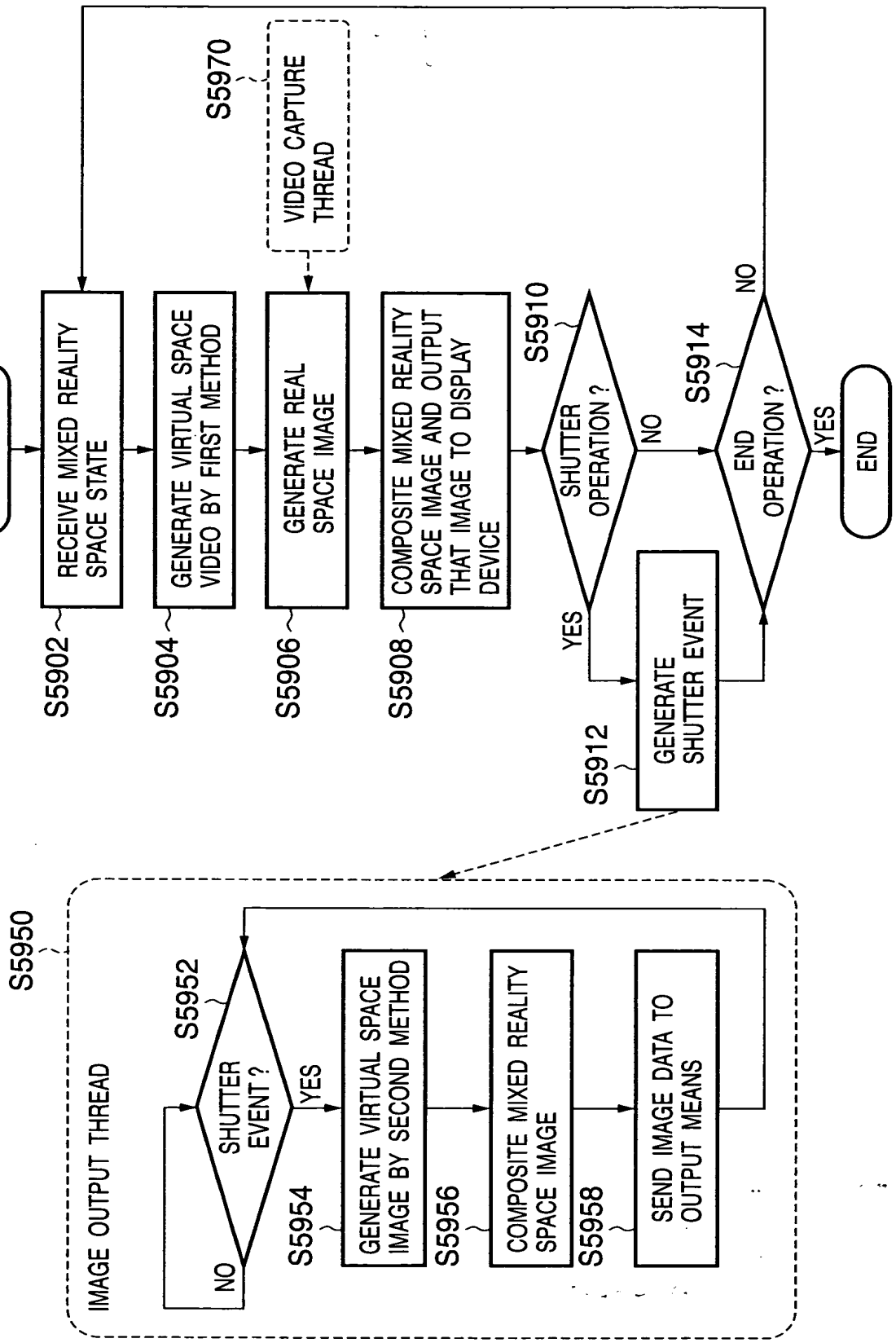
START
RECEIVE MIXED REALITY SPACE STATE
S5902
GENERATE VIRTUAL SPACE VIDEO BY FIRST METHOD
S5904
GENERATE REAL SPACE IMAGE
S5906
COMPOSITE MIXED REALITY SPACE IMAGE AND OUTPUT THAT IMAGE TO DISPLAY DEVICE
S5908
S5910
SHUTTER OPERATION ?
YES
NO
S5912
GENERATE SHUTTER EVENT
S5914
END OPERATION ?
NO
YES
END
S5970
VIDEO CAPTURE THREAD
S5950
IMAGE OUTPUT THREAD
S5952
SHUTTER EVENT ?
NO
YES
S5954
GENERATE VIRTUAL SPACE IMAGE BY SECOND METHOD
S5956
COMPOSITE MIXED REALITY SPACE IMAGE
S5958
SEND IMAGE DATA TO OUTPUT MEANS

FIG. 34

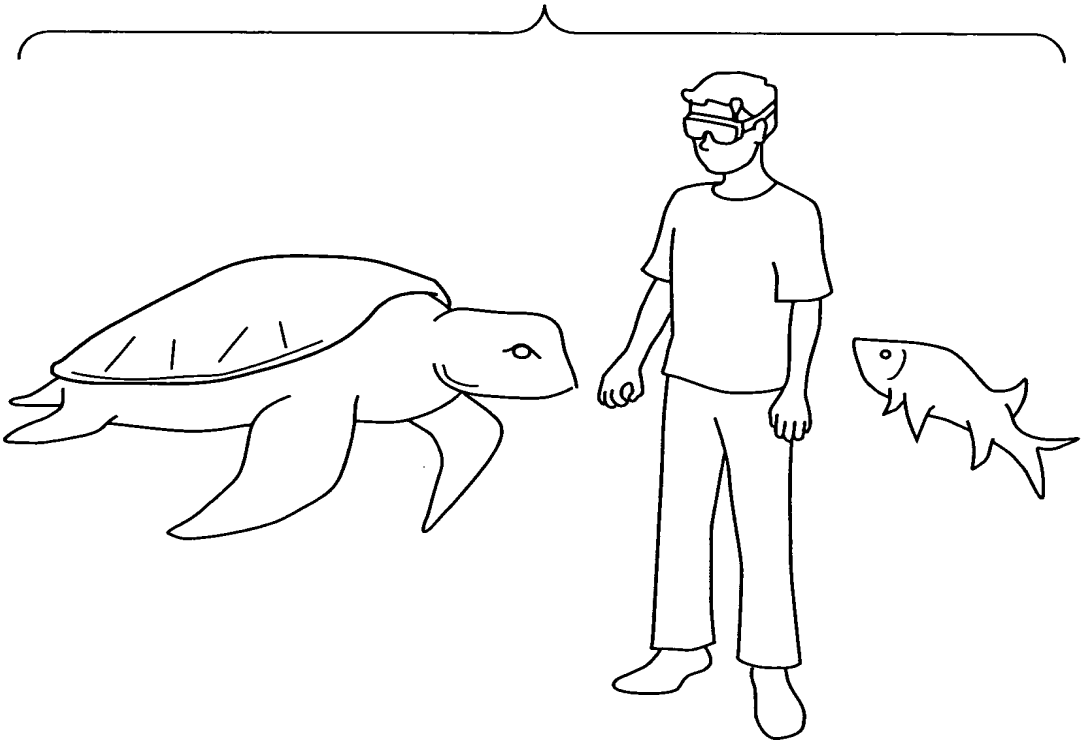

FIG. 35

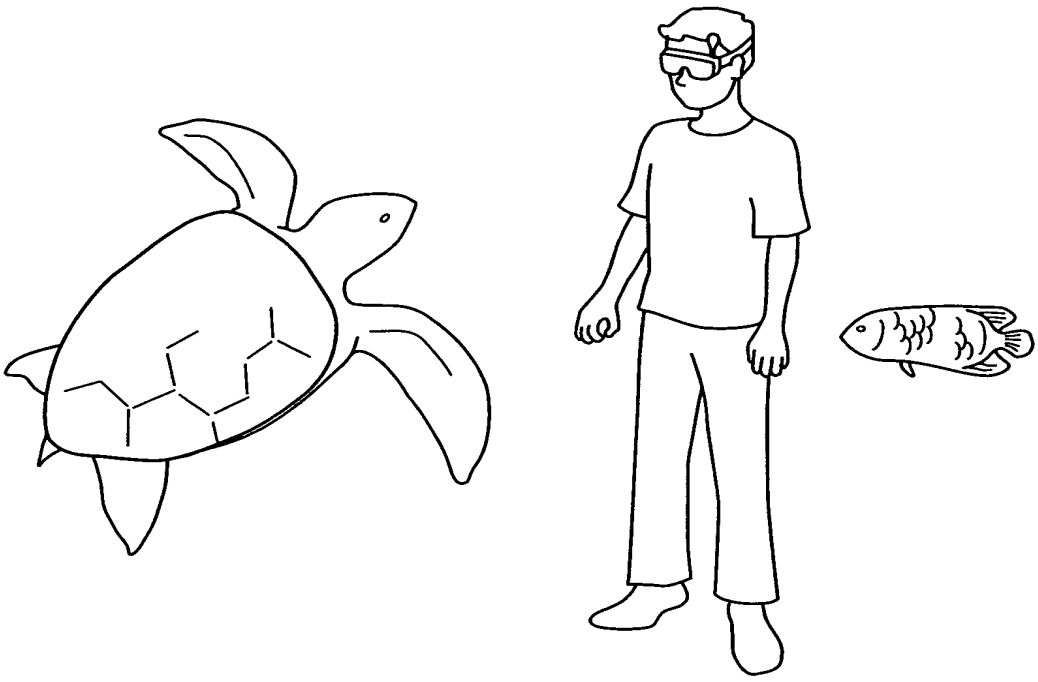

FIG. 36

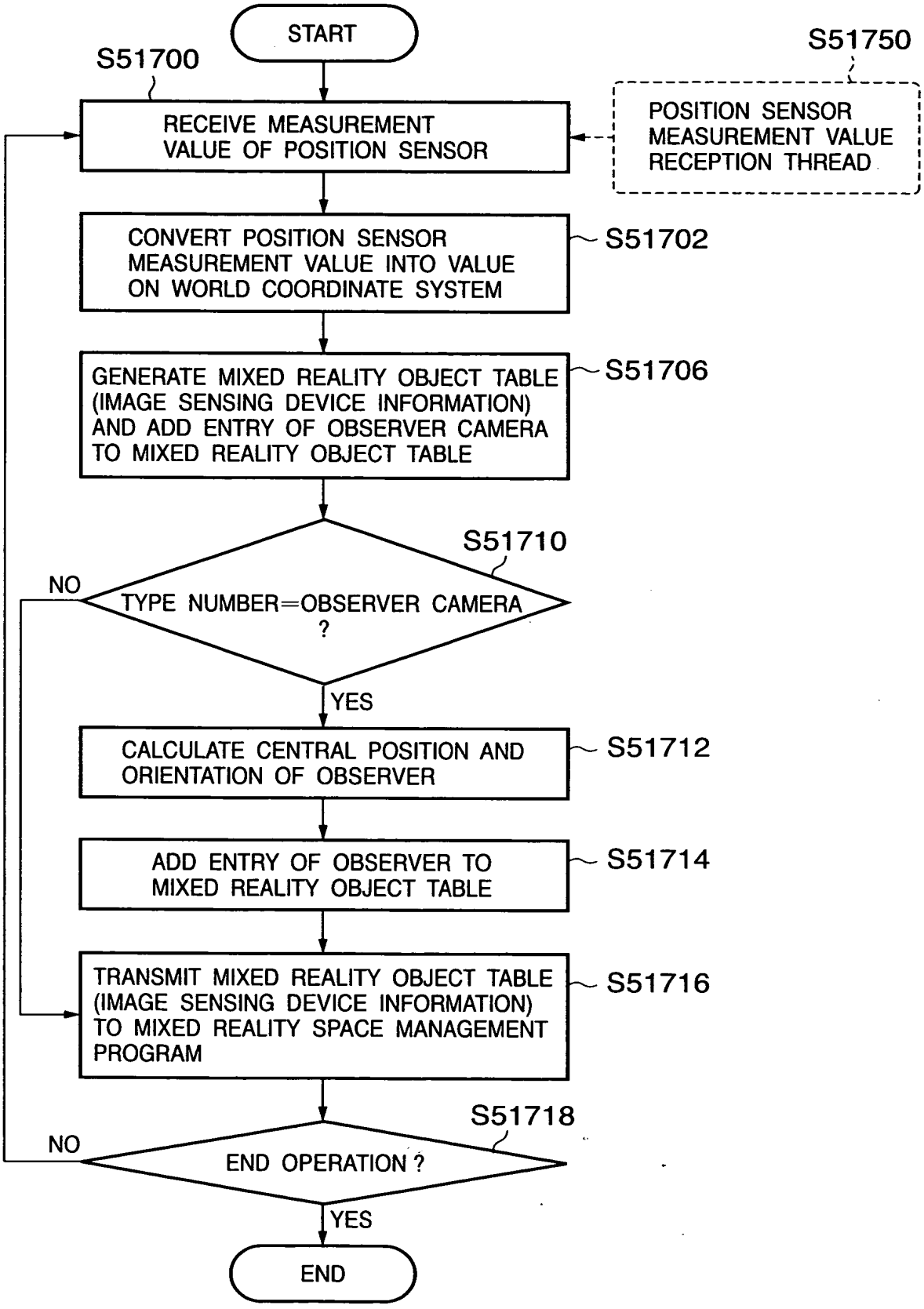
START
S51700
RECEIVE MEASUREMENT VALUE OF POSITION SENSOR
S51750
POSITION SENSOR MEASUREMENT VALUE RECEPTION THREAD
CONVERT POSITION SENSOR MEASUREMENT VALUE INTO VALUE ON WORLD COORDINATE SYSTEM
S51702
GENERATE MIXED REALITY OBJECT TABLE (IMAGE SENSING DEVICE INFORMATION) AND ADD ENTRY OF OBSERVER CAMERA TO MIXED REALITY OBJECT TABLE
S51706
S51710
TYPE NUMBER=OBSERVER CAMERA ?
NO
YES
CALCULATE CENTRAL POSITION AND ORIENTATION OF OBSERVER
S51712
ADD ENTRY OF OBSERVER TO MIXED REALITY OBJECT TABLE
S51714
TRANSMIT MIXED REALITY OBJECT TABLE (IMAGE SENSING DEVICE INFORMATION) TO MIXED REALITY SPACE MANAGEMENT PROGRAM
S51716
S51718
END OPERATION ?
NO
YES
END

FIG. 37

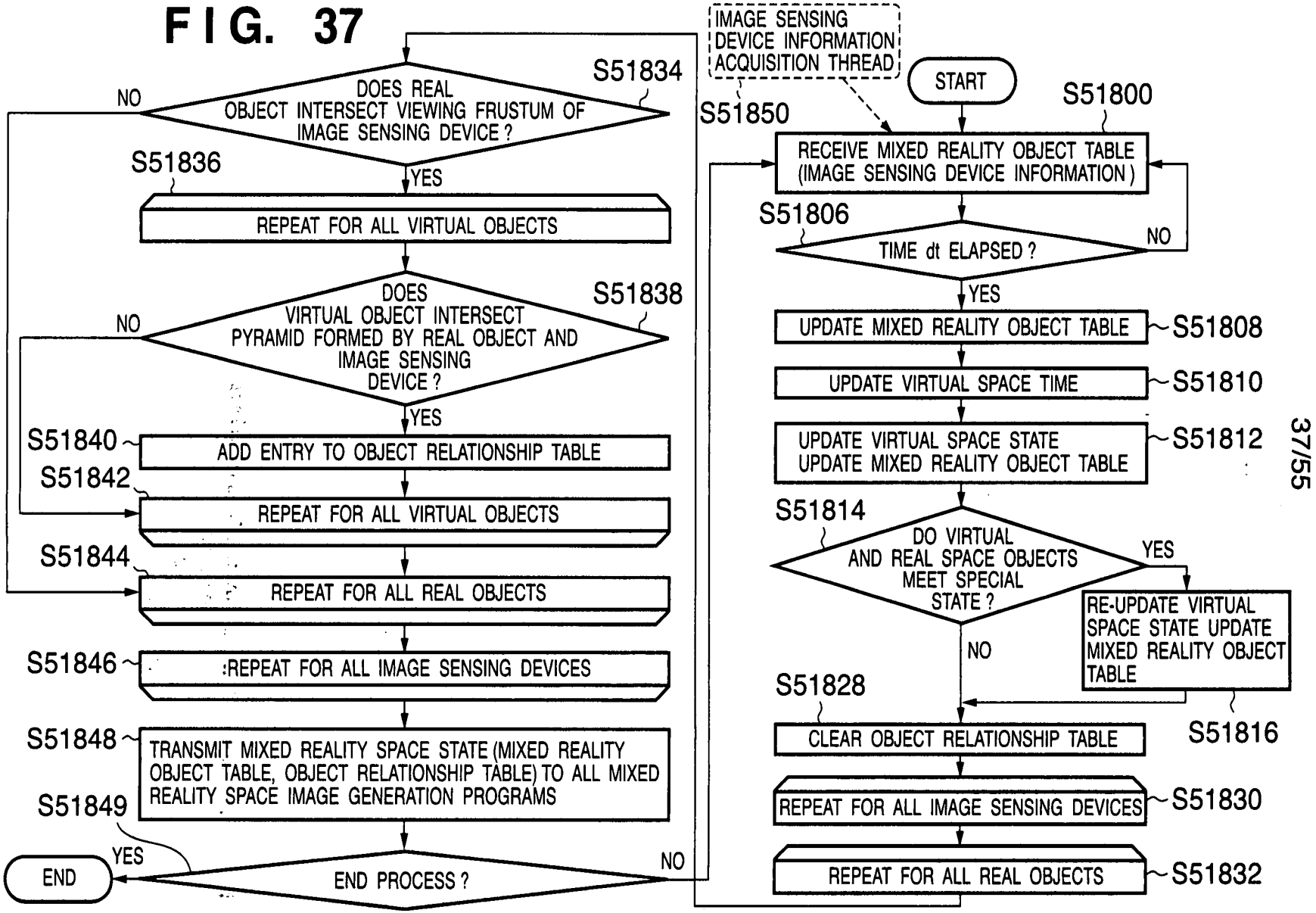
IMAGE SENSING DEVICE INFORMATION ACQUISITION THREAD
START
S51800
S51850
RECEIVE MIXED REALITY OBJECT TABLE (IMAGE SENSING DEVICE INFORMATION)
S51806
TIME dt ELAPSED ?
NO
YES
UPDATE MIXED REALITY OBJECT TABLE
S51808
UPDATE VIRTUAL SPACE TIME
S51810
UPDATE VIRTUAL SPACE STATE
UPDATE MIXED REALITY OBJECT TABLE
S51812
S51814
DO VIRTUAL AND REAL SPACE OBJECTS MEET SPECIAL STATE ?
YES
NO
RE-UPDATE VIRTUAL SPACE STATE UPDATE MIXED REALITY OBJECT TABLE
S51816
S51828
CLEAR OBJECT RELATIONSHIP TABLE
REPEAT FOR ALL IMAGE SENSING DEVICES
S51830
REPEAT FOR ALL REAL OBJECTS
S51832
S51834
DOES REAL OBJECT INTERSECT VIEWING FRUSTUM OF IMAGE SENSING DEVICE ?
NO
YES
S51836
REPEAT FOR ALL VIRTUAL OBJECTS
S51838
DOES VIRTUAL OBJECT INTERSECT PYRAMID FORMED BY REAL OBJECT AND IMAGE SENSING DEVICE ?
NO
YES
S51840
ADD ENTRY TO OBJECT RELATIONSHIP TABLE
S51842
REPEAT FOR ALL VIRTUAL OBJECTS
S51844
REPEAT FOR ALL REAL OBJECTS
S51846
REPEAT FOR ALL IMAGE SENSING DEVICES
S51848
TRANSMIT MIXED REALITY SPACE STATE (MIXED REALITY OBJECT TABLE, OBJECT RELATIONSHIP TABLE) TO ALL MIXED REALITY SPACE IMAGE GENERATION PROGRAMS
S51849
END PROCESS ?
YES
NO
END

FIG. 38

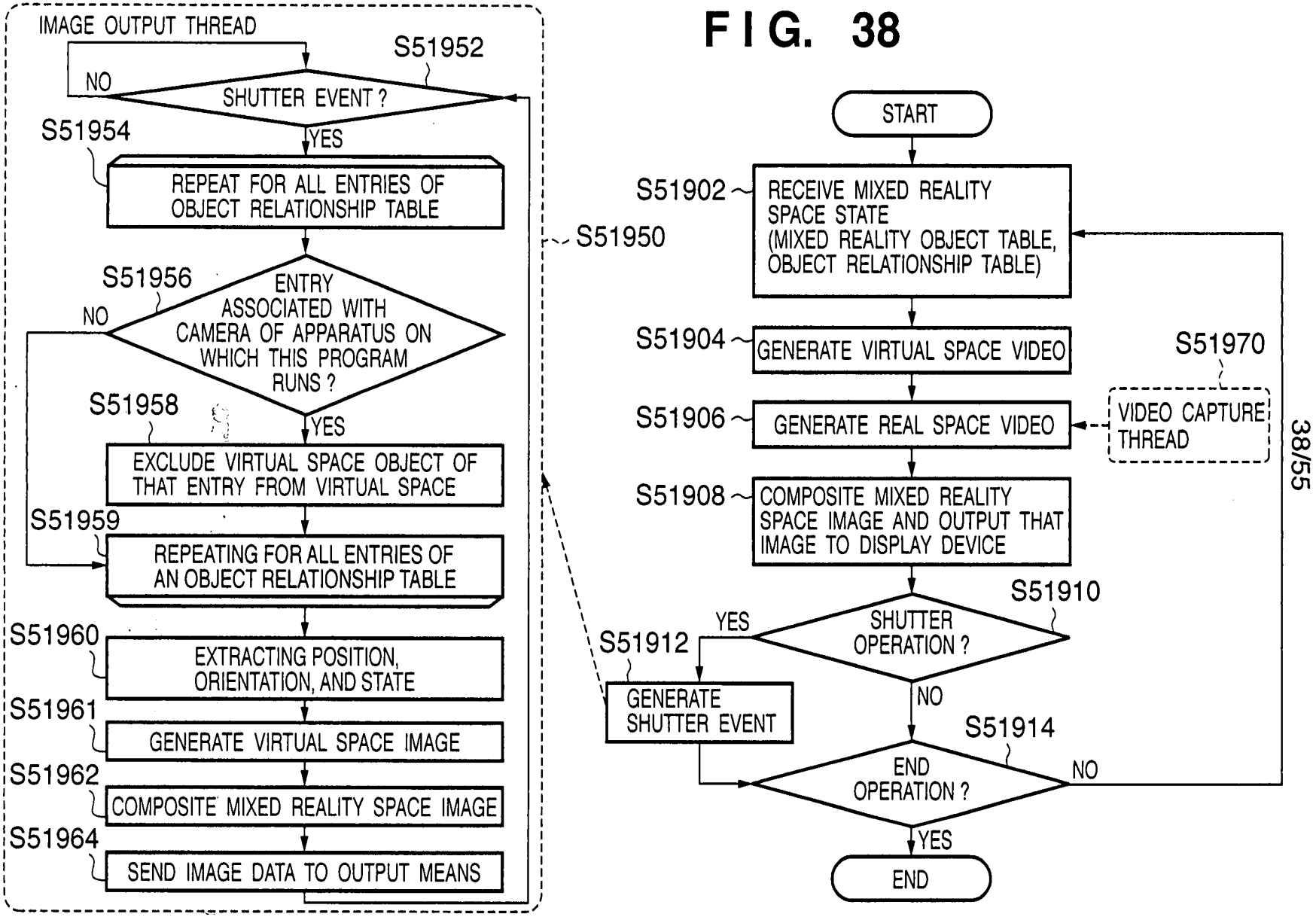
IMAGE OUTPUT THREAD
S51952
NO
SHUTTER EVENT ?
YES
S51954
REPEAT FOR ALL ENTRIES OF OBJECT RELATIONSHIP TABLE
S51956
ENTRY ASSOCIATED WITH CAMERA OF APPARATUS ON WHICH THIS PROGRAM RUNS ?
NO
YES
S51958
EXCLUDE VIRTUAL SPACE OBJECT OF THAT ENTRY FROM VIRTUAL SPACE
S51959
REPEATING FOR ALL ENTRIES OF AN OBJECT RELATIONSHIP TABLE
S51960
EXTRACTING POSITION, ORIENTATION, AND STATE
S51961
GENERATE VIRTUAL SPACE IMAGE
S51962
COMPOSITE MIXED REALITY SPACE IMAGE
S51964
SEND IMAGE DATA TO OUTPUT MEANS
S51950
START
S51902
RECEIVE MIXED REALITY SPACE STATE (MIXED REALITY OBJECT TABLE, OBJECT RELATIONSHIP TABLE)
S51904
GENERATE VIRTUAL SPACE VIDEO
S51970
VIDEO CAPTURE THREAD
S51906
GENERATE REAL SPACE VIDEO
S51908
COMPOSITE MIXED REALITY SPACE IMAGE AND OUTPUT THAT IMAGE TO DISPLAY DEVICE
S51910
SHUTTER OPERATION ?
YES
S51912
GENERATE SHUTTER EVENT
NO
S51914
END OPERATION ?
NO
YES
END

FIG. 39

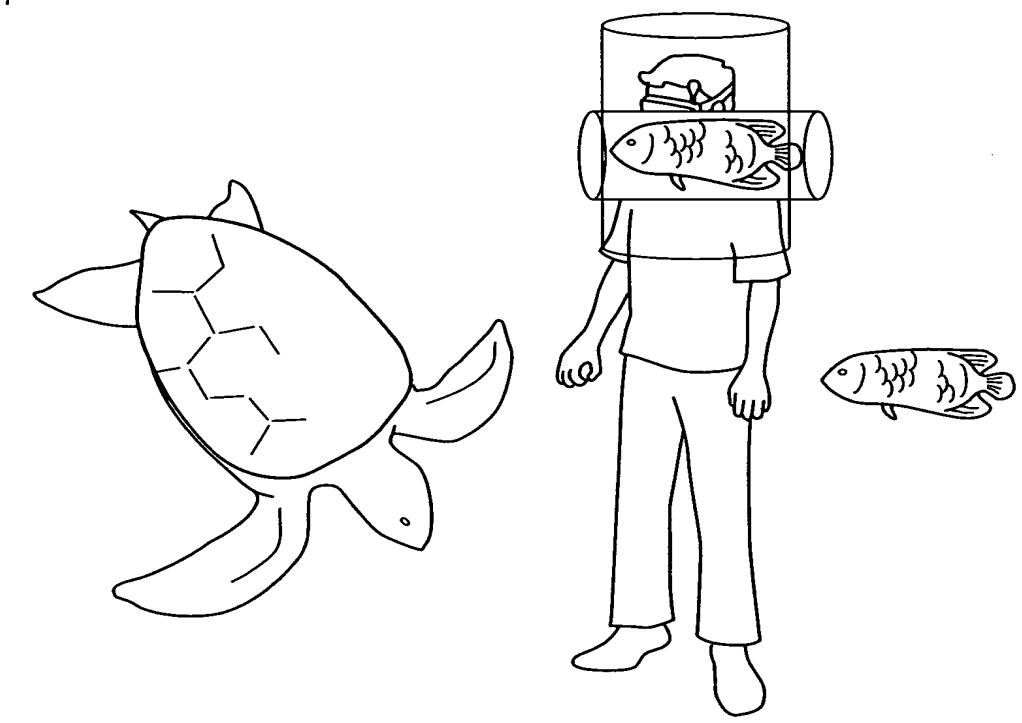

FIG. 40

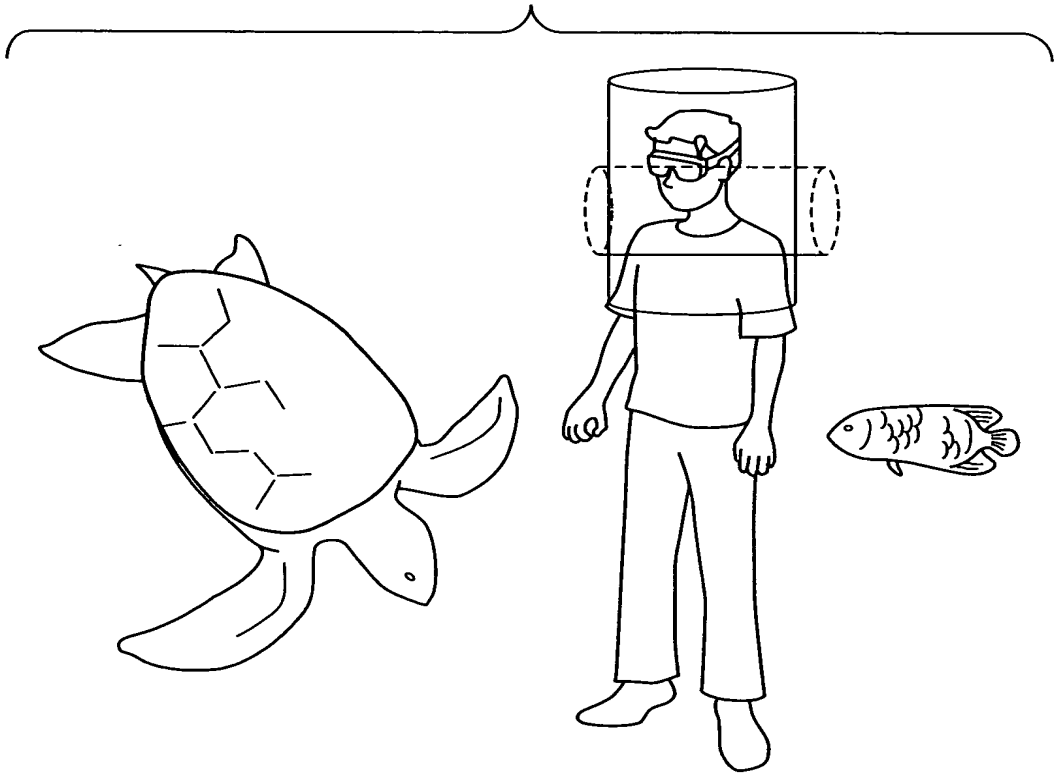

FIG. 41

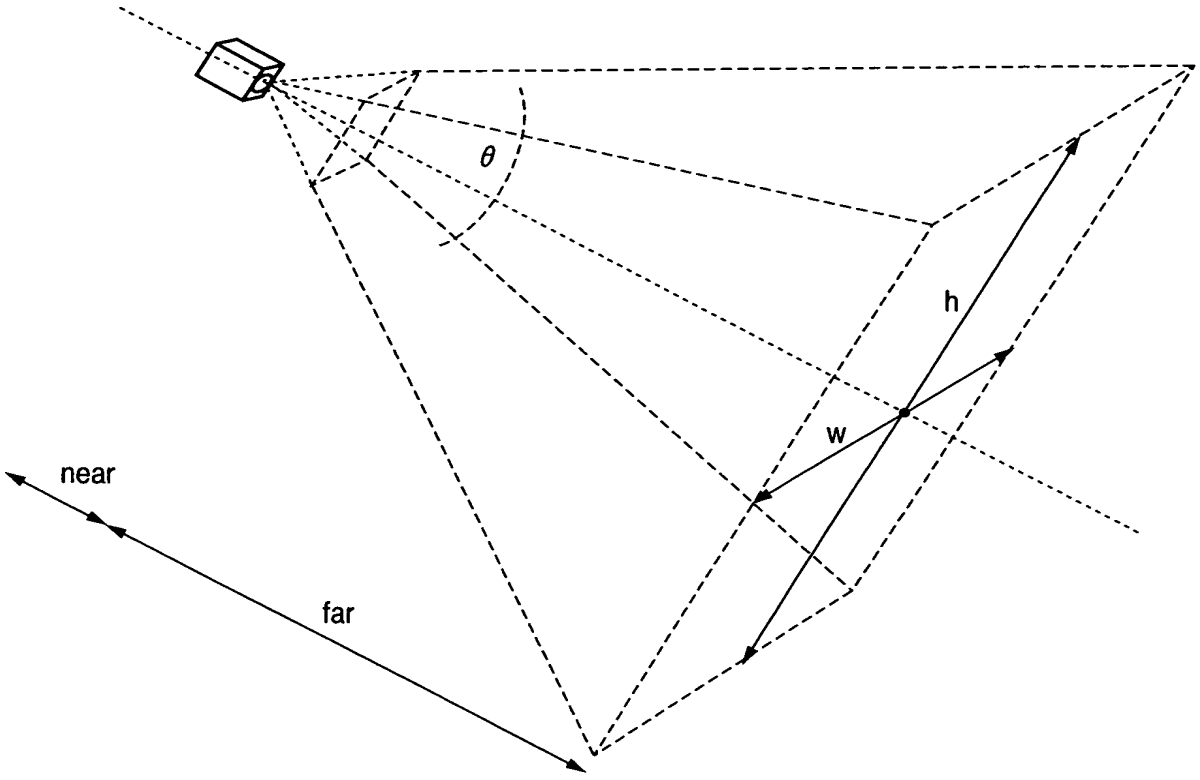

FIG. 42

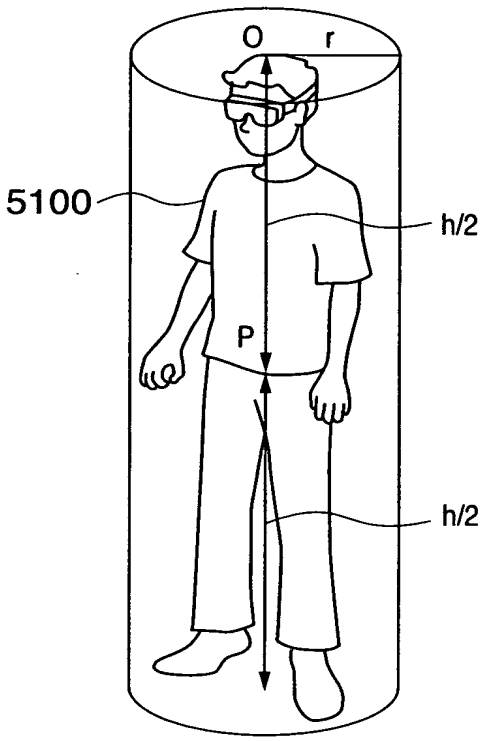

FIG. 43

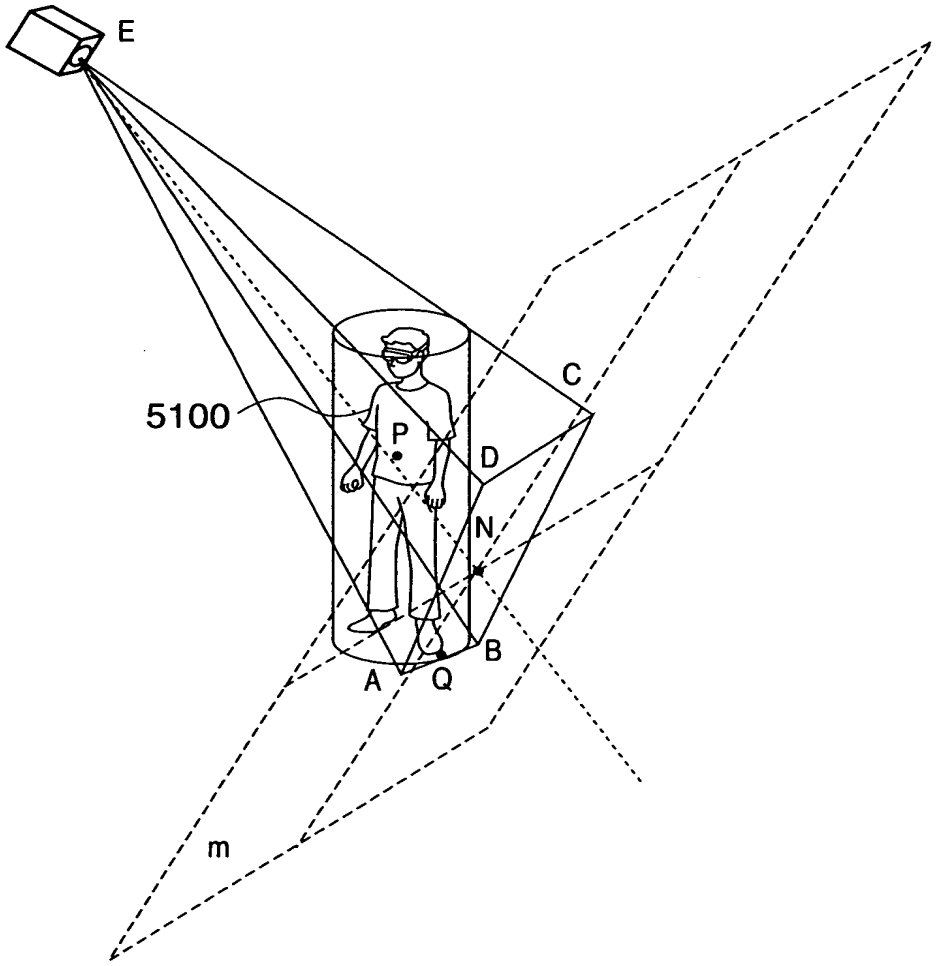

FIG. 44

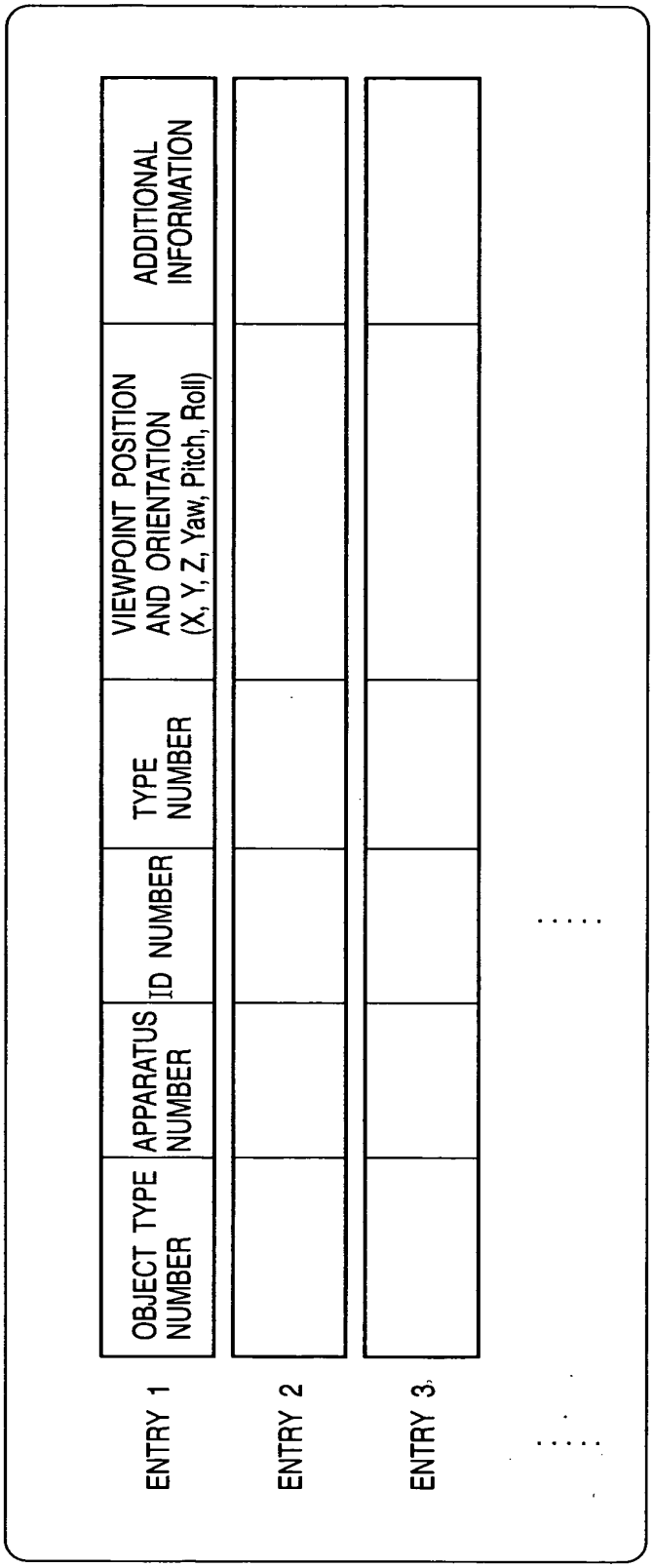
OBJECT TYPE NUMBER
APPARATUS NUMBER
ID NUMBER
TYPE NUMBER
VIEWPOINT POSITION AND ORIENTATION (X, Y, Z, Yaw, Pitch, Roll)
ADDITIONAL INFORMATION
ENTRY 1
ENTRY 2
ENTRY 3

FIG. 45

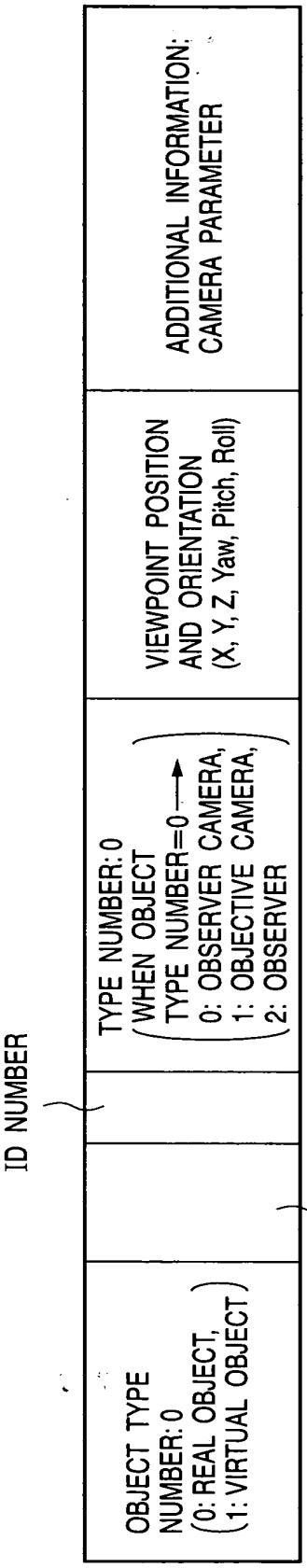
OBJECT TYPE
NUMBER: 0
(0: REAL OBJECT,
1: VIRTUAL OBJECT)
ID NUMBER
APPARATUS
NUMBER
TYPE NUMBER: 0
(WHEN OBJECT
TYPE NUMBER=0
0: OBSERVER CAMERA,
1: OBJECTIVE CAMERA,
2: OBSERVER)
VIEWPOINT POSITION
AND ORIENTATION
(X, Y, Z, Yaw, Pitch, Roll)
ADDITIONAL INFORMATION:
CAMERA PARAMETER

FIG. 46

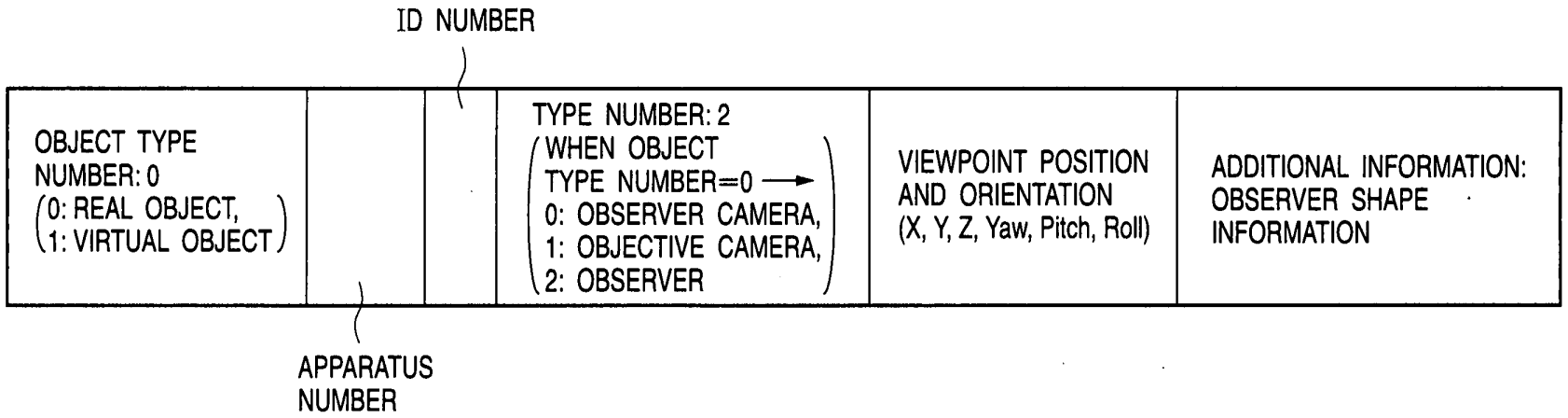
ID NUMBER
OBJECT TYPE NUMBER: 0 (0: REAL OBJECT, 1: VIRTUAL OBJECT)
TYPE NUMBER: 2 (WHEN OBJECT TYPE NUMBER=0 → 0: OBSERVER CAMERA, 1: OBJECTIVE CAMERA, 2: OBSERVER)
VIEWPOINT POSITION AND ORIENTATION (X, Y, Z, Yaw, Pitch, Roll)
ADDITIONAL INFORMATION: OBSERVER SHAPE INFORMATION
APPARATUS NUMBER

FIG. 47

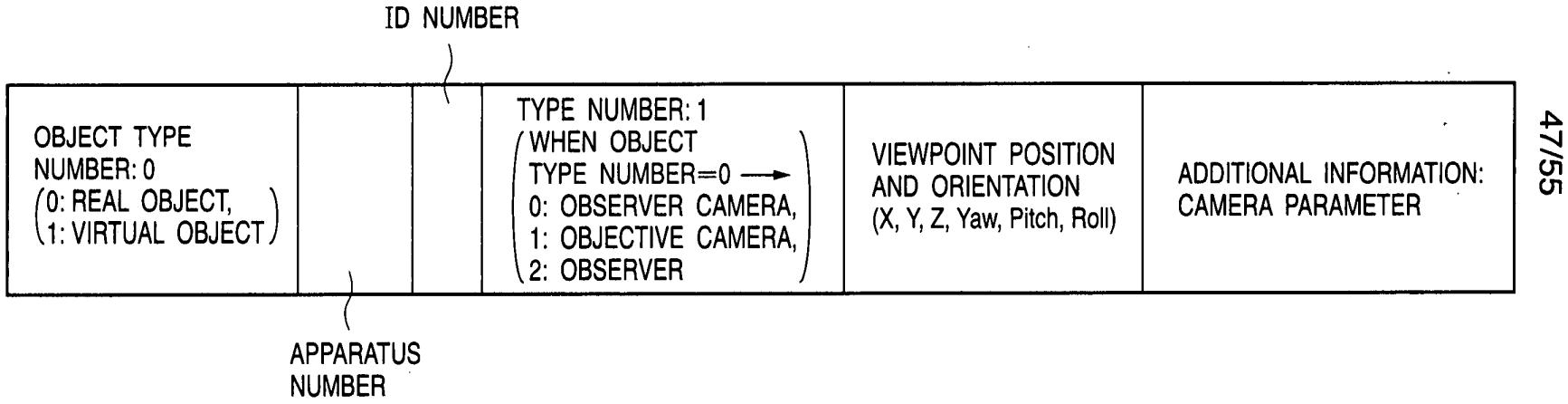
ID NUMBER
OBJECT TYPE NUMBER: 0 (0: REAL OBJECT, 1: VIRTUAL OBJECT)
TYPE NUMBER: 1 (WHEN OBJECT TYPE NUMBER=0 → 0: OBSERVER CAMERA, 1: OBJECTIVE CAMERA, 2: OBSERVER)
VIEWPOINT POSITION AND ORIENTATION (X, Y, Z, Yaw, Pitch, Roll)
ADDITIONAL INFORMATION: CAMERA PARAMETER
APPARATUS NUMBER

FIG. 48

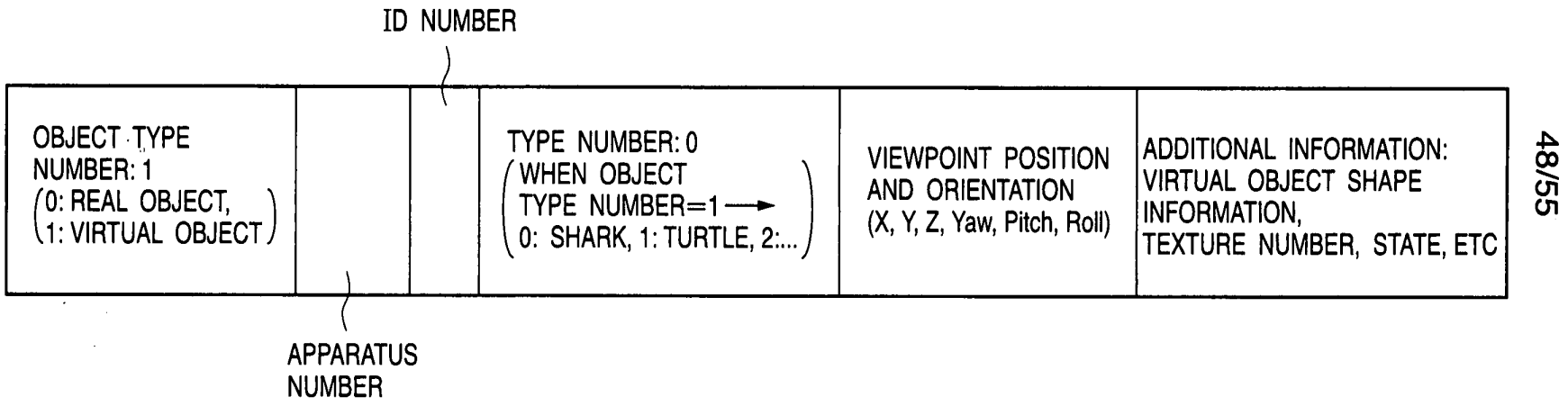
ID NUMBER
OBJECT TYPE NUMBER: 1 (0: REAL OBJECT, 1: VIRTUAL OBJECT)
TYPE NUMBER: 0 (WHEN OBJECT TYPE NUMBER=1 → 0: SHARK, 1: TURTLE, 2:...)
VIEWPOINT POSITION AND ORIENTATION (X, Y, Z, Yaw, Pitch, Roll)
ADDITIONAL INFORMATION: VIRTUAL OBJECT SHAPE INFORMATION, TEXTURE NUMBER, STATE, ETC
APPARATUS NUMBER

FIG. 49

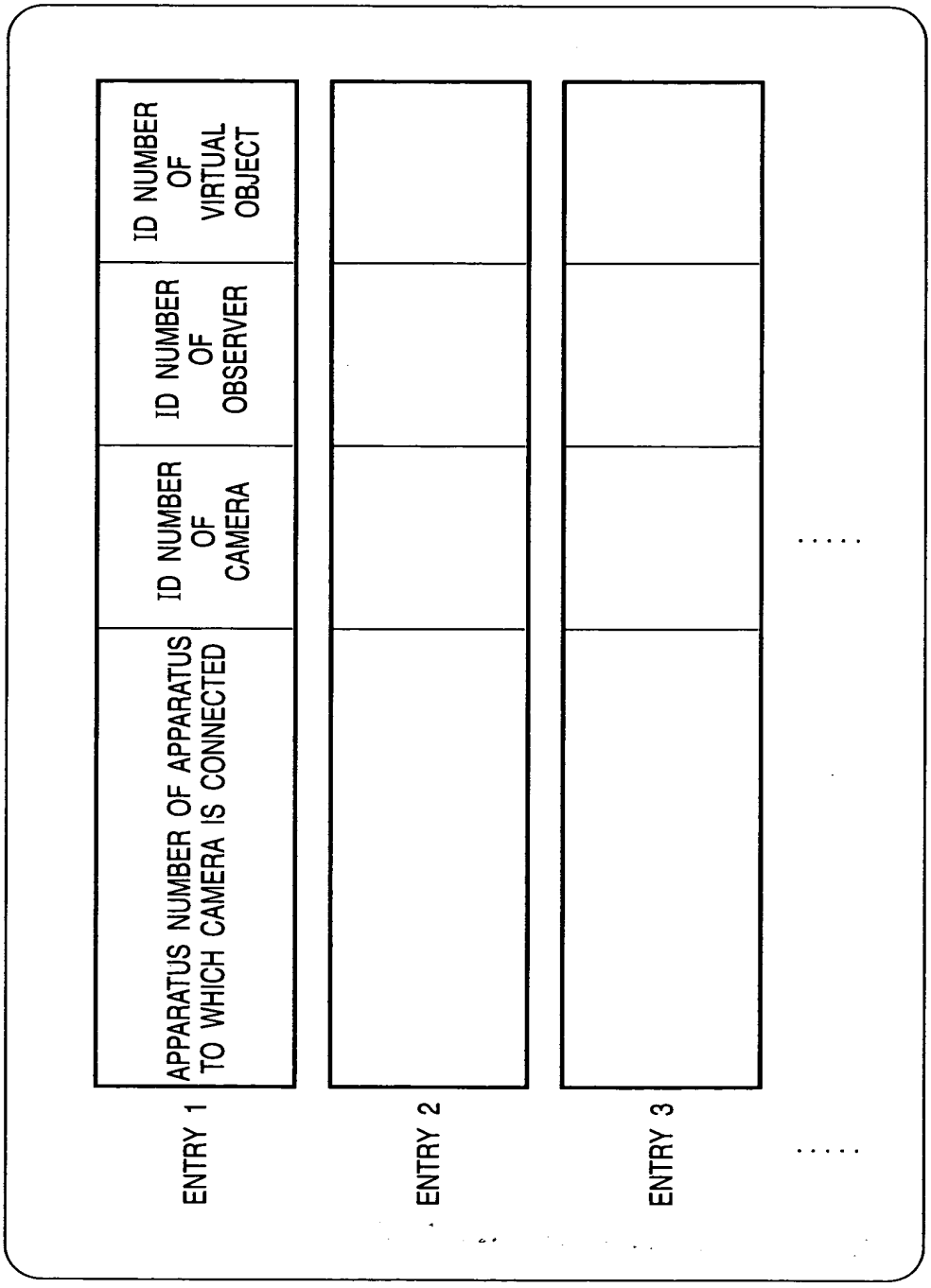
ENTRY 1
APPARATUS NUMBER OF APPARATUS TO WHICH CAMERA IS CONNECTED
ID NUMBER OF CAMERA
ID NUMBER OF OBSERVER
ID NUMBER OF VIRTUAL OBJECT
ENTRY 2
ENTRY 3

FIG. 50

APPARATUS NUMBER OF APPARATUS TO WHICH CAMERA IS CONNECTED : 1	ID NUMBER OF CAMERA : 1	ID NUMBER OF OBSERVER : 2	ID NUMBER OF VIRTUAL OBJECT : 6

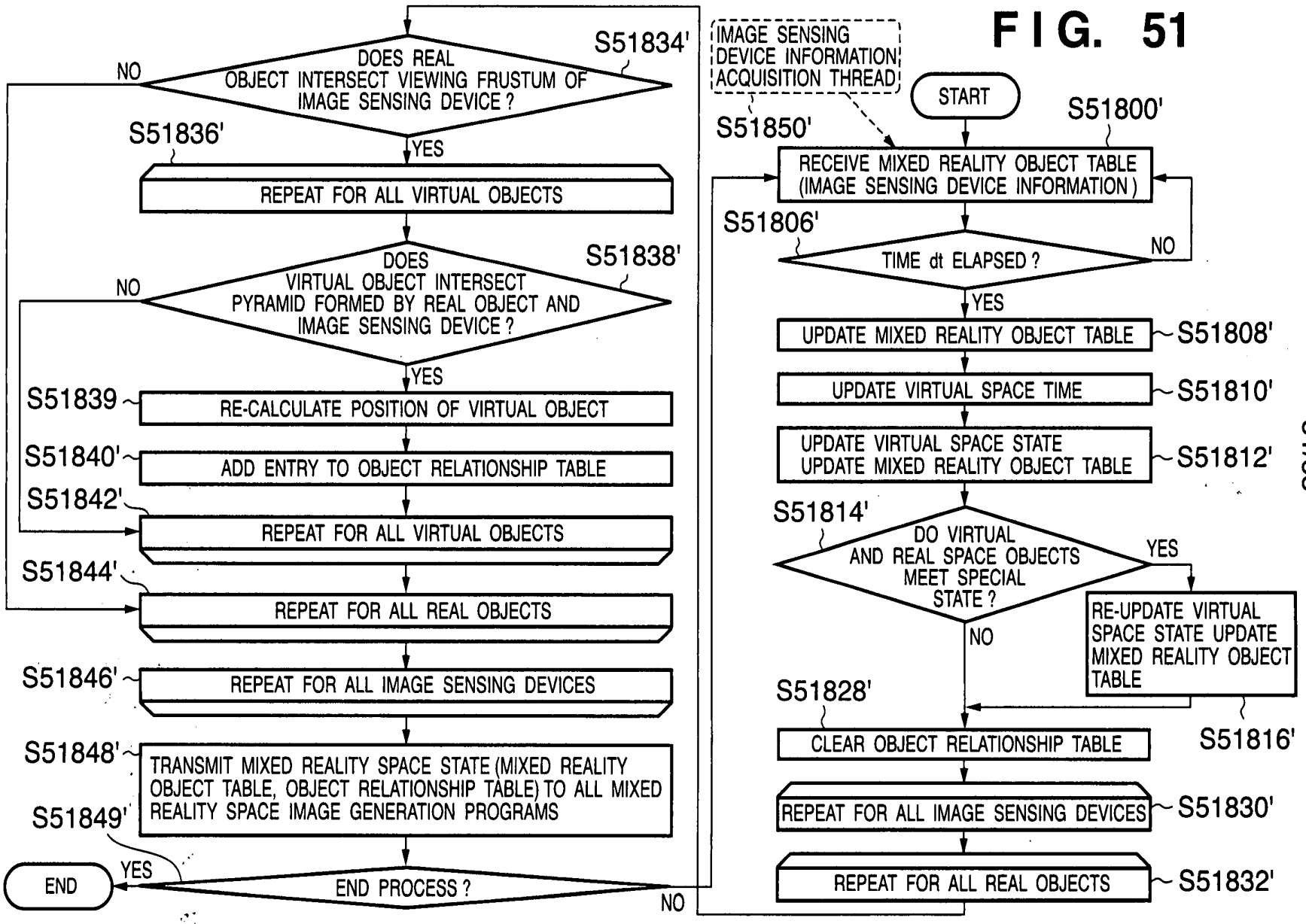
IMAGE SENSING DEVICE INFORMATION ACQUISITION THREAD
START
S51800'
S51850'
RECEIVE MIXED REALITY OBJECT TABLE (IMAGE SENSING DEVICE INFORMATION)
S51806'
TIME dt ELAPSED ?
NO
YES
UPDATE MIXED REALITY OBJECT TABLE
S51808'
UPDATE VIRTUAL SPACE TIME
S51810'
UPDATE VIRTUAL SPACE STATE
UPDATE MIXED REALITY OBJECT TABLE
S51812'
S51814'
DO VIRTUAL AND REAL SPACE OBJECTS MEET SPECIAL STATE ?
YES
NO
RE-UPDATE VIRTUAL SPACE STATE UPDATE MIXED REALITY OBJECT TABLE
S51816'
S51828'
CLEAR OBJECT RELATIONSHIP TABLE
REPEAT FOR ALL IMAGE SENSING DEVICES
S51830'
REPEAT FOR ALL REAL OBJECTS
S51832'
S51834'
DOES REAL OBJECT INTERSECT VIEWING FRUSTUM OF IMAGE SENSING DEVICE ?
NO
YES
S51836'
REPEAT FOR ALL VIRTUAL OBJECTS
S51838'
DOES VIRTUAL OBJECT INTERSECT PYRAMID FORMED BY REAL OBJECT AND IMAGE SENSING DEVICE ?
NO
YES
S51839
RE-CALCULATE POSITION OF VIRTUAL OBJECT
S51840'
ADD ENTRY TO OBJECT RELATIONSHIP TABLE
S51842'
REPEAT FOR ALL VIRTUAL OBJECTS
S51844'
REPEAT FOR ALL REAL OBJECTS
S51846'
REPEAT FOR ALL IMAGE SENSING DEVICES
S51848'
TRANSMIT MIXED REALITY SPACE STATE (MIXED REALITY OBJECT TABLE, OBJECT RELATIONSHIP TABLE) TO ALL MIXED REALITY SPACE IMAGE GENERATION PROGRAMS
S51849'
END
YES
END PROCESS ?
NO

FIG. 51

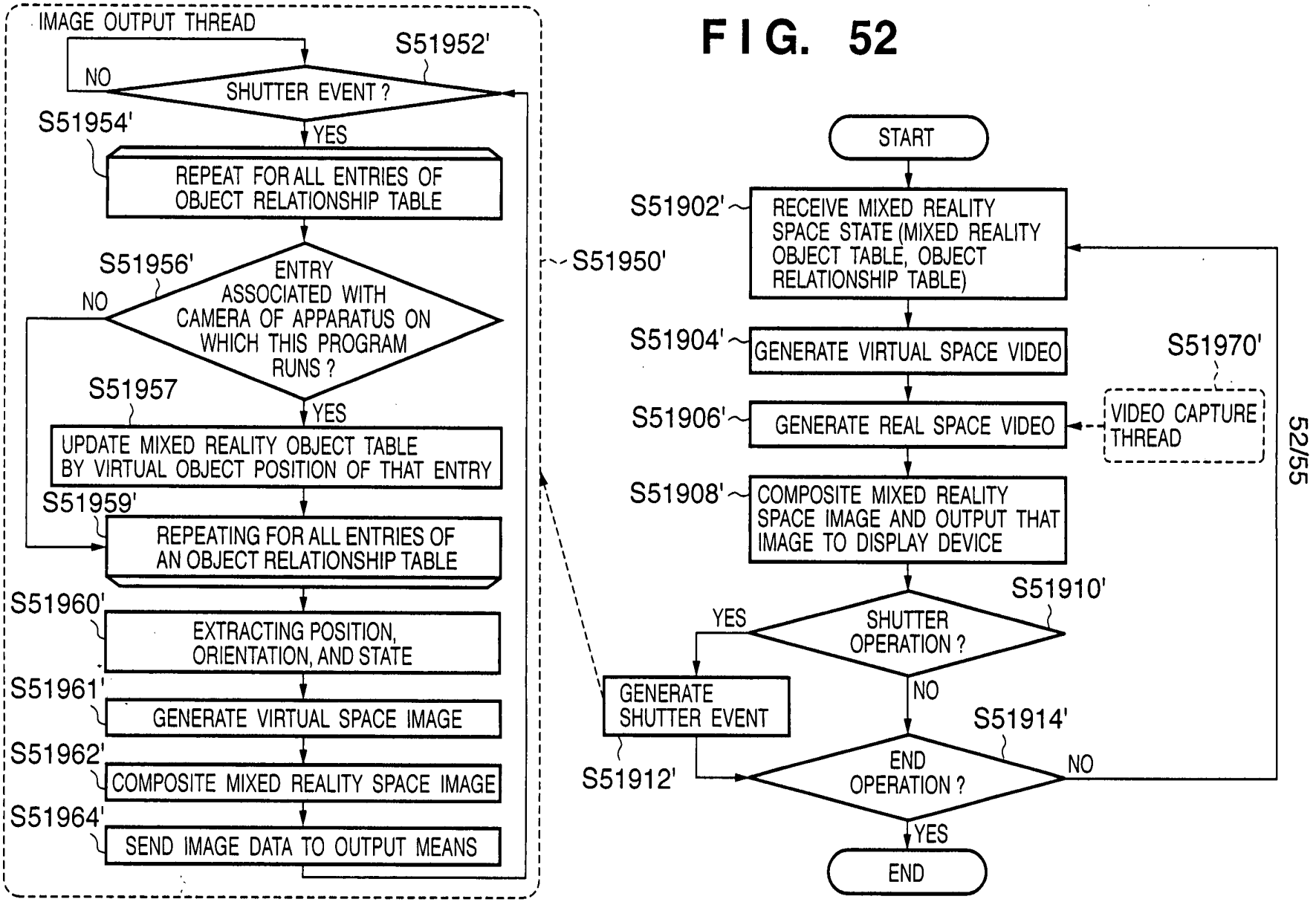
IMAGE OUTPUT THREAD
S51952'
NO
SHUTTER EVENT ?
YES
S51954'
REPEAT FOR ALL ENTRIES OF OBJECT RELATIONSHIP TABLE
S51956'
ENTRY ASSOCIATED WITH CAMERA OF APPARATUS ON WHICH THIS PROGRAM RUNS ?
NO
YES
S51957
UPDATE MIXED REALITY OBJECT TABLE BY VIRTUAL OBJECT POSITION OF THAT ENTRY
S51959'
REPEATING FOR ALL ENTRIES OF AN OBJECT RELATIONSHIP TABLE
S51960'
EXTRACTING POSITION, ORIENTATION, AND STATE
S51961'
GENERATE VIRTUAL SPACE IMAGE
S51962'
COMPOSITE MIXED REALITY SPACE IMAGE
S51964'
SEND IMAGE DATA TO OUTPUT MEANS
S51950'
START
S51902'
RECEIVE MIXED REALITY SPACE STATE (MIXED REALITY OBJECT TABLE, OBJECT RELATIONSHIP TABLE)
S51904'
GENERATE VIRTUAL SPACE VIDEO
S51970'
S51906'
GENERATE REAL SPACE VIDEO
VIDEO CAPTURE THREAD
S51908'
COMPOSITE MIXED REALITY SPACE IMAGE AND OUTPUT THAT IMAGE TO DISPLAY DEVICE
S51910'
SHUTTER OPERATION ?
YES
NO
GENERATE SHUTTER EVENT
S51912'
S51914'
END OPERATION ?
NO
YES
END
52/55

FIG. 52

FIG. 53

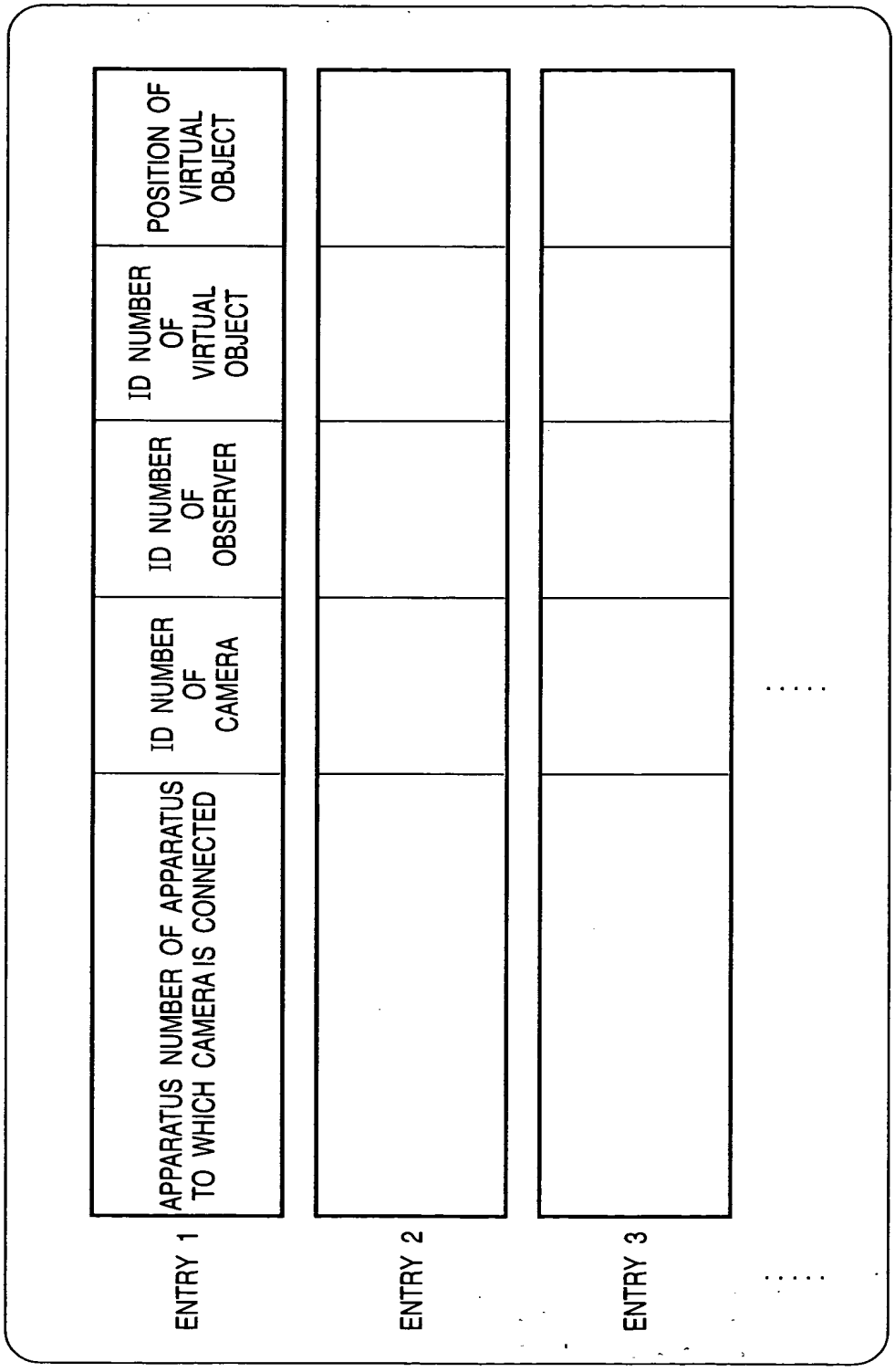
APPARATUS NUMBER OF APPARATUS TO WHICH CAMERA IS CONNECTED
ID NUMBER OF CAMERA
ID NUMBER OF OBSERVER
ID NUMBER OF VIRTUAL OBJECT
POSITION OF VIRTUAL OBJECT
ENTRY 1
ENTRY 2
ENTRY 3

FIG. 54

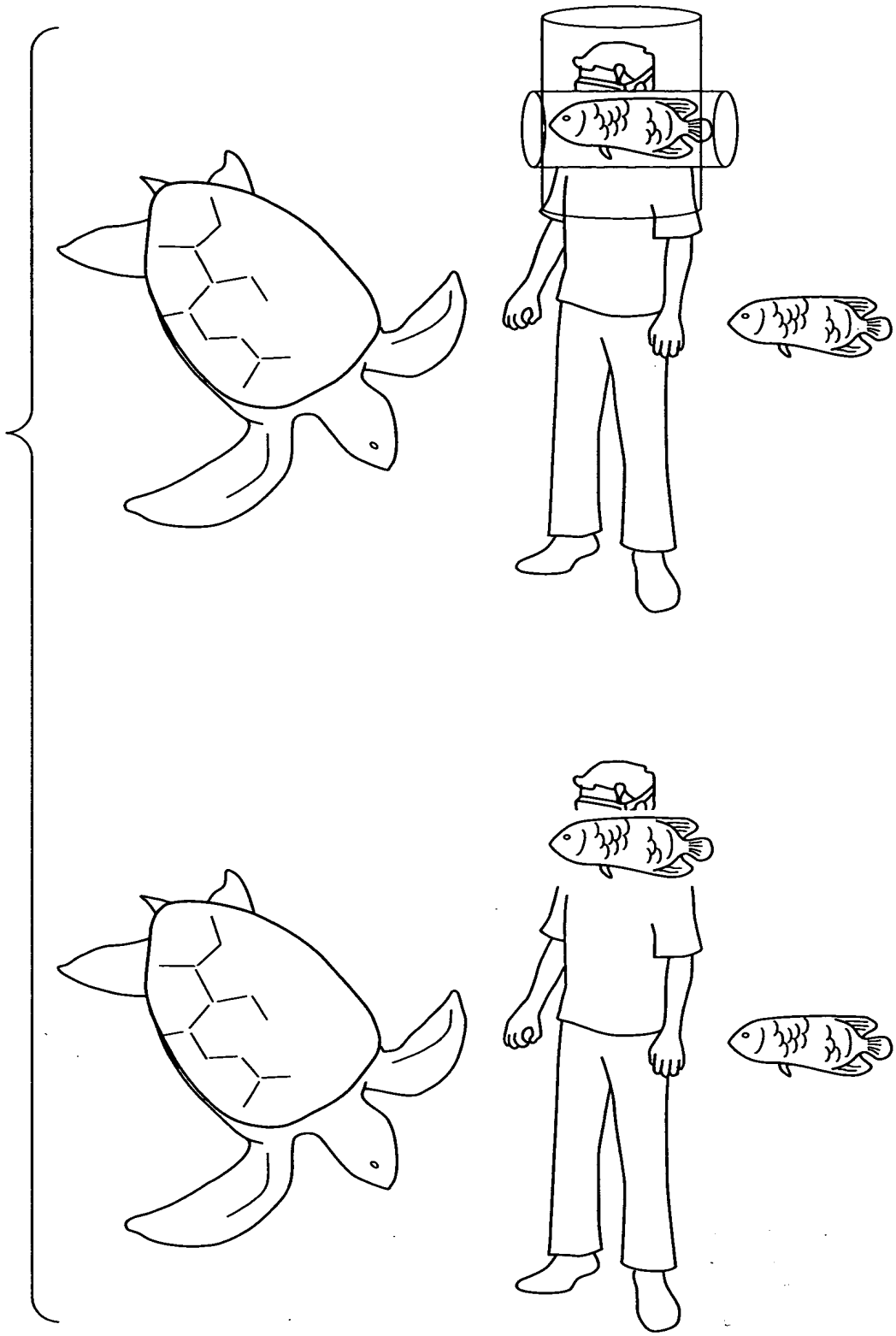
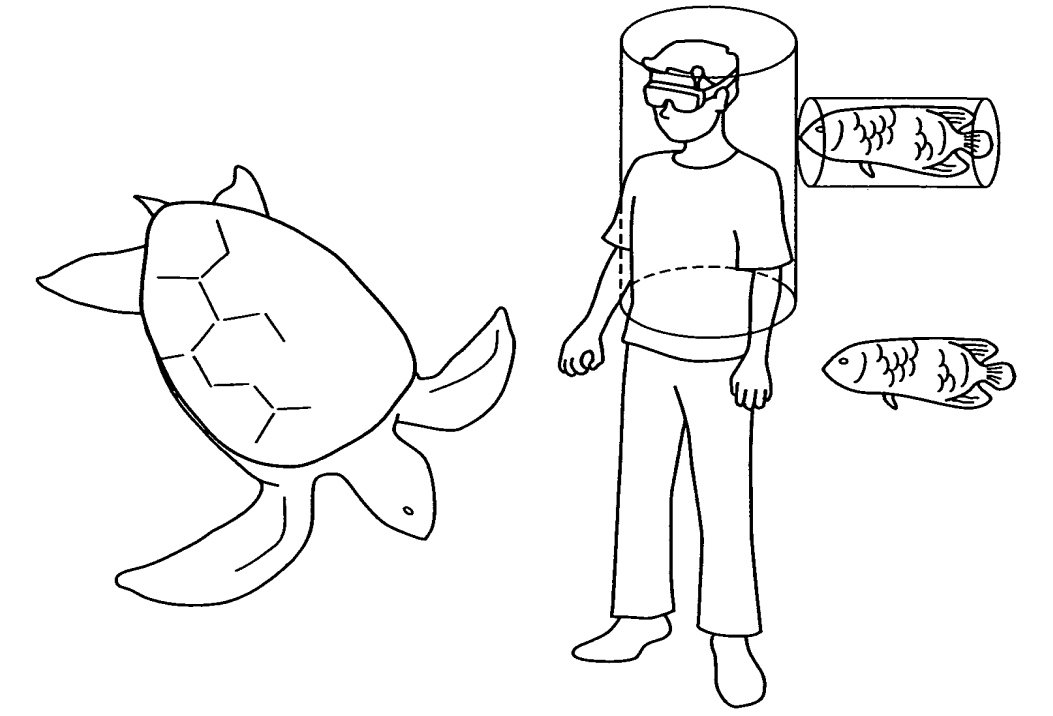
FIG. 55